Engineering News

Vol. 68, No. 23 505 Pearl Street, New York December 5, 1912

English Tower Cranes for Building Construction

A type of erecting plant used very extensively in England in the construction of large buildings consists of a tower composed of three or four framed legs surmounted by a platform carrying a stiff-leg derrick. The platform is at an elevation above that of the top of the building, and in buildings of moderate area one tower and crane will serve the entire work. The legs of the tower are rectangular, built up of heavy plank, and very generally bolted together in sections, so that they may readily be taken down and reassembled. It would seem at first sight that these legs would greatly interfere with the structural work, but we are informed that there is rarely any trouble of this kind, the legs being so located as to occupy floor panels which can be filled in after removal of the tower, or to occupy openings left for elevators, stairways, etc.

In Fig. 1 is shown one of these tower cranes on the site of a new building in Gracechurch St., London. This has four framed legs braced together and connected at the top by trusses, the whole framework supporting the working platform and crane. The platform is 115 ft. above the street level, and the top of the crane mast is 144 ft. above that level. The tower foundations extend 50 ft. below the ground. A very similar equipment was employed in the building of an extension to the Imperial Hotel, London, and served a site 150x100 ft. In this case the towers were 8 ft. square, spaced 30 ft. between centers, and had a height of 120 ft. from the street level to the working platform. The crane mast was 100 ft. high, giving a total height of 220 ft. above the street. It handled a boom having a maximum reach of 80 ft., with a hoisting capacity of six tons. This structure was built by James Smith & Sons, contractors, South Norwood, London (England).

Another type of tower crane used in England has a steel braced tower or mast traveling on a track laid along the face of the work, and in cities this track may be laid on a trestle which forms the sidewalk shelter. In some cases the two outer legs of the tower are inclined inward near the bottom and unite with the inner legs, the mast running on a single rail, which may be laid along the inner side of the sidewalk, causing very little obstruction. In this case, a longitudinal runway is erected at about one-fourth or one-third the height of the tower, for wheels which serve to steady and guide it in moving. The boom is pivoted over one leg of the tower. The machinery and operating house may be placed at the top or bottom or at any intermediate height, to suit the convenience in each case.

The boom may have a fixed reach, or it may have a luffing or topping motion, with variable reach. Fig. 2 shows a traveling tower crane, with a single rail, an operating house at the base, and a boom of fixed radius. The cranes of this type are built with a height up to 100 ft., a working radius of 10 to 35 ft., and a hoisting capacity of one to five tons. Fig. 3 shows a heavier crane with a fixed tower, operating house at the top, and a topping lift to vary the reach of the crane. A special feature of these topping-lift cranes is that the load remains at the same height while the reach of the boom is being varied; in other words, the load has a horizontal movement in vary-

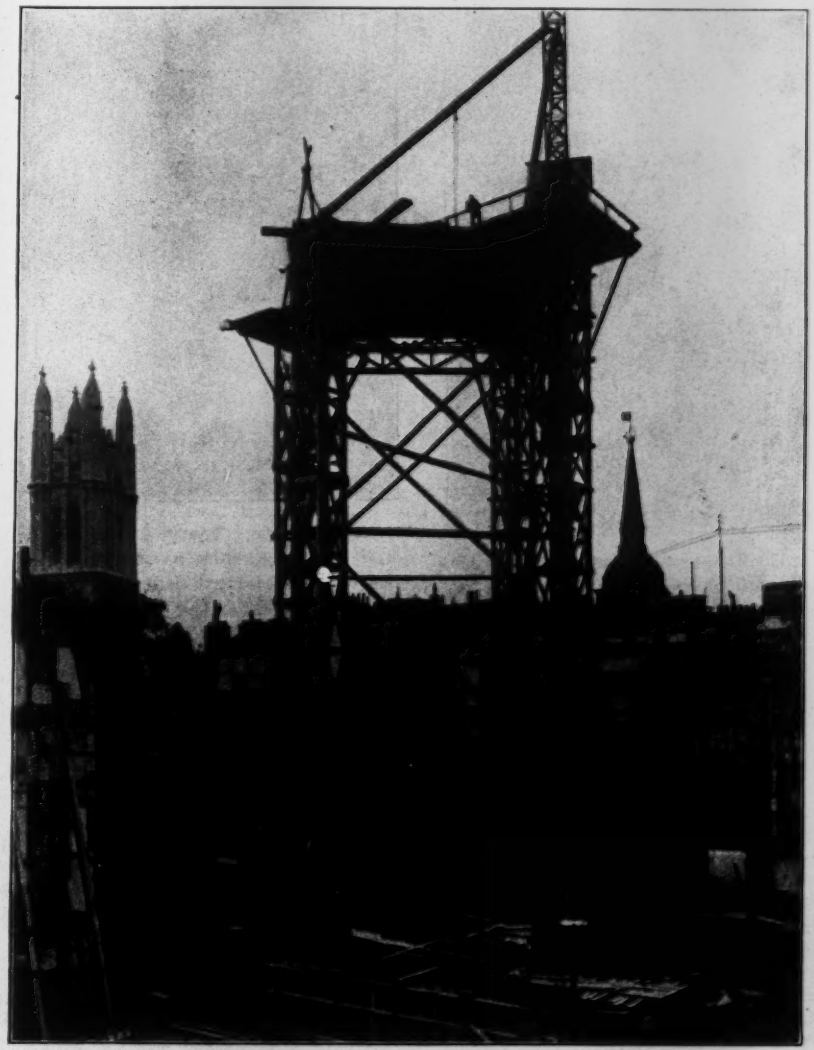


FIG. 1. TOWER CRANE FOR THE ERECTION OF A BUILDING IN LONDON (ENGLAND)

ing its distance from the tower. This result is obtained by a special arrangement of the hoisting ropes, which may be seen in Fig. 3. Instead of being led from the head of the boom direct to the hoisting drum they are led in a special direction from the boom to the mast and then to the drum.

In this way the resultant compressive stress due to the load on one side of the boom and the pull of the hoisting ropes on the other side passes along the boom and through its pivot. Thus the boom has no tendency to vary its angle or to revolve on its horizontal pivot when a load is applied, and the topping-lift is not required to support the boom and load. The boom moves very freely also, and in the smaller sizes the working radius is varied by simply pushing the load, which (as explained above) moves in a horizontal path.

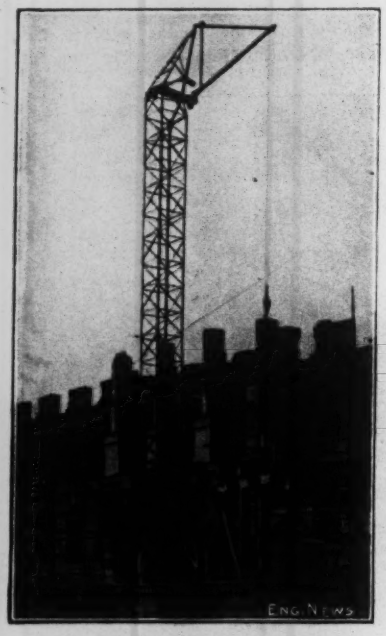


FIG. 2. TRAVELING TOWER CRANE; WITH BRACED STEEL TOWER RUNNING ON A SINGLE RAIL

A crane somewhat similar to that shown in Fig. 1 has a triangular steel tower formed by three triangular legs. Power is furnished by a continually running motor (electric or gasoline) of small size, which gives a high speed for hoisting. As to this arrangement, the maker's statement is as follows: "This crane has one small continually running motor which constantly runs on an even load lifting a counterweight. The various motions of lifting, slewing and luffing are operated by allowing the counterweight to fall."

The three types of steel tower cranes mentioned above are built by Herbert Morris & Bastert, Empress Works, Loughborough, England.

Performance of a Dipper Dredge Driven by Oil Engines on Drainage Ditch Excavation

Dipper dredges operated by oil engines were described in ENGINEERING NEWS, of Sept. 12, and we have received particulars of the working performance of one of these machines. This is dredge No. 3, belonging to D. C. Stephens, contractor, of Buffalo, N. Y., and working on a drainage ditch in Iowa. It was built by the Marion Steam Shovel Co., and has two Fairbanks-Morse horizontal oil engines at the ends of the main pinion shaft for operating the hoisting, backing and spud drums. The swinging drums are operated by a small steam engine. The dipper is of 2½ yd. capacity. The following information as to the performance has been furnished us by H. B. Whiting, superintendent of the work, at Villisca, Ia.

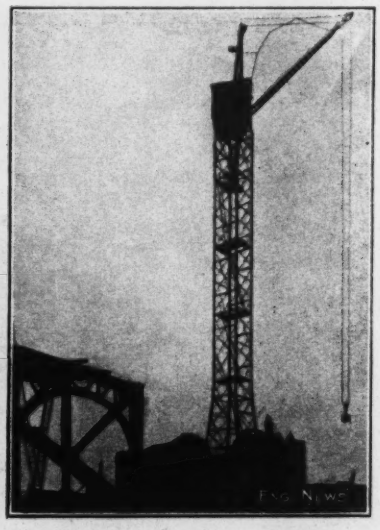


FIG. 3. STATIONARY TOWER CRANE, WITH SPECIAL ARRANGEMENT OF ROPES

(The boom is balanced in any position, and the load travels in a horizontal path, as the reach of the boom is varied.)

The work during October was constructing a drainage ditch having 25 ft. bottom width from station 116 + 50 to station 130 + 50. Then the dredge cut upstream in a ditch having 20 ft. bottom width and 10 to 16 ft. depth. This part of the ditch being on a flat grade, the dredge cut 3 ft. below paid excavation in order that the grade line would remain clear of silt while the dredge was cutting the outlet. The excess material excavated in this part does not enter into the yardage of excavation in the performance record given in the accompanying table.

The dredge reached the Chicago & Northwestern Ry. tracks and moved back to turn and clean the ditch below grade through the hard material, about 1400 ft. It then remained idle to have a larger air-compressor installed, furnace rebuilt in boiler and other repairs made. Some of the material excavated was very hard. One serious delay was encountered when a bottom plank on the boat was torn loose and its hull filled nearly to the decks. The forward spuds and the stern resting on the bank prevented the dredge from sinking.

The expense of oil for fuel was a fraction under $27 for 24 hr. when fuel oil and kerosene mixed was used, and a fraction under $25 per day when 40-gravity distillate was used. Coal (from Franklin County, Illinois) would have cost $50 per day, in addition to extra expense for hauling that would have been incurred by reason of high water overflowing the surface.

TABLE OF PERFORMANCE OF AN OIL-OPERATED DREDGE

(The figures include only the excavation paid for, in accordance with the engineer's estimate.)

October 1912	Distance cut Day ft.	Distance cut Night cu.yd.	Excavation Day ft.	Excavation Night cu.yd.	Total Excav. cu.yd.
25 ft. bottom width.					
1	130	120	2,650	2,715	5,365
2	150	130	2,615	2,628	5,243
3	165	200	2,674	3,254	5,928
4	170	200	3,387	3,263	6,650
5	250	165	5,035	3,291	8,326
6	...	200	...	3,965	3,965
7	200	...	4,025	.....	4,025
8	150	150	3,122	2,965	6,087
9	250	250	4,967	5,065	10,032
10	200	200	3,830	4,025	7,855
11	230	200	4,529	4,162	8,691
12	100	220	3,427	4,884	8,311
20-ft. bottom width:					
13	...	50	...	1,225	1,225
14	50	...	1,125	.....	1,125
15	165	185	3,018	2,840	5,858
16	300	200	5,291	3,535	8,826
17	200	200	2,869	2,967	5,836
18	150	150	2,215	2,150	4,365
19	...	...	...	.....	.....
20	...	200	...	3,051	3,051
21	75	...	1,317	.....	1,317
22	100	50	1,654	854	2,508
23	225	175	3,760	2,806	6,566
24	175	175	3,267	2,988	6,255
25	150	150	2,684	3,111	5,795
26	50	125	703	1,954	2,657
Total for 23 working days					135,882 cu.yd.

The oil is unloaded by gravity flow from tank-car to storage tanks and pumped from the latter to a tank-wagon; it is pumped again from the wagon to a 1000-gal. tank on a small scow, from which it is delivered to the dredge as needed.

The labor employed consists of the following force: 2 Dredge operators, 2 Dredge cranesmen, 2 Enginemen, 2 Deck hands, 1 Laborer to look after oil, 1 Cook, 1 Supt. in charge, 1 Team to haul oil.

Road Improvement in Louisiana for the year 1912, is estimated to cost about $2,311,000, according to figures compiled by C. C. Sandoz, Secretary of the State Highway Department, Board of State Engineers. This total cost is divided as follows: Parish expenditures, $1,131,322; expenditures by New Orleans, $468,576; expenditure by other incorporated municipalities, $547,164; contracts let by State Highway Department, during 1912, $131,694; state-aid convict camps building state roads, $32,220.

Tests of the Strength of Creosoted Bridge Timbers

An extended series of tests of bridge timbers* of long-leaf yellow pine has been made by the Atchison, Topeka & Santa Fé R.R., in order to investigate the effect of creosote treatment (by the full-cell process) upon the strength of the timber. A description of the investigations, by H. B. MacFarland, Engineer of Tests, has been published in Bulletin No. 149 (September, 1912) of the American Railway Engineering Association, and we give herewith a summary of the results. The timbers tested were 32 standard stringers 7x16 in., 28 ft. long, taken from stock and all in first-class condition, although no attempt was made to pick out the best pieces. They had been seasoned for about ten months; most of them had a large percentage of sapwood. Each timber was cut in half (the parts being properly marked for identification), and one half was creosoted.

Mr. MacFarland states that the U. S. Engineers have demonstrated that the employment of the boiling process in treating weakens timber to a very marked degree, as the high temperature used in steaming tends to break down the cell-wall structure. As there is no steaming process in the full-cell treatment used at the timber-treating plants of the A., T. & S. F. R.R., it has been the opinion that the timber was not materially weakened by this treatment. It is very important that this should be determined definitely, as creosoted timber is now being used extensively in bridges and trestles.

In the treated sticks, the penetration of the creosote was very variable, from very slight to practically complete; the absorption ranged from 7 to 21 lb. per cu.ft. The most important factors which influence the penetration are the density of the wood (indicated by the number of growth-rings per inch) and the presence of pitch in the winter-growth rings. The penetration is better where the number of rings is small, and is very poor where the winter-growth contains much pitch. A greater percentage of moisture seems to increase rather than decrease the penetration. The general character of the treatment was as follows:

Oil transferred to cyl.	11:50 a. m.
Pump started	12:10 p. m.
Temp. of oil in tank	200° F.
Temp. of oil in cyl.	170° F.
Max. pressure	150 lb.
Time of max. press.	1:40 p.m.
Oil to ground tank	2:25 p.m.
Vacuum started	2:45 p.m.
Vacuum broken	4:15 p.m.
Max. vacuum	26 in.
Run closed	4:30 p.m.
Total time	4 hr. 40 min.

Effect of Creosoting

Immediately after Treatment—The results show that there is very little difference in the strength of the treated and untreated timber directly after treatment. Some of the creosoted specimens show a greater modulus of rupture than the untreated half of the same timber, but by referring to the records, causes for the differences in these individual cases may be found. The average modulus of rupture for untreated specimens is 5% greater than that for treated. The horizontal shearing strength also shows 2% higher for the untreated. The elastic properties are very nearly identical. The percentage of moisture seems to have a considerable bearing on the strength of the timber. Most of the pieces treated were quite dry, averaging about 20% moisture; a piece containing 55% had a modulus of rupture of 4670 lb., while a piece containing only 13½% had a modulus of rupture of 6160 lb.

Only 15 out of the 64 specimens failed in tension, the remainder failing by horizontal shear. The presence of season checks and heart shakes seems to be the main factor in influencing the horizontal shear failures. A number of knots near the neutral axis, on the contrary, seems to prevent horizontal shearing. In compression parallel to the grain, the superiority of the untreated specimens is more marked; the elastic limit being 10% greater, the modulus of elasticity 9% greater, and the maximum load 9% greater. In compression perpendicular to the grain, the untreated specimens also show somewhat better than the treated, though the difference is only 2 or 3%. No conclusions should be drawn from this statement since the physical properties referred to are approximated from the curves.

One Year After Treatment—The average amount of creosote injected was 13.7 lb. per cu.ft. for the timbers which were tested immediately after treatment, and the specimens tested one year after treatment showed 13.3 lb. per cu.ft.; the average loss of creosote by weathering was 3.7 lb. per cu.ft.

The results of the timbers tested one year after treatment show in the transverse tests that the strength was greatly increased. In compression parallel to the grain, the average results show an increase of 10%. In compression perpendicular to the grain, the elastic limit shows less, but otherwise an increase in strength is shown. The accompanying table shows the average strengths of the treated timbers when tested immediately after treatment and when tested one year after treatment, as compared with that of unreated timbers.

Conclusions

Mr. MacFarland sates that the results show conclusively that long-leaf pine timber which has been subjected to the full-cell process of creosoting and allowed to weather for a year is in no way inferior to untreated timber in strength When tested immediately after treatment, the results show the treated timber to be slightly inferior to the untreated timber.

TABLE I. TRANSVERSE TESTS

Specimen	Elastic Limit lb. per sq.in.	Modulus Rupture lb. per sq.in.	Modulus of Elasticity lb. per sq.in.	Deflection at Failure in.	Maximum Horizontal Shear lb. per sq.in.
January, 1911					
Untreated	4,260	5,160	1,595,000	1.15	415
Treated	4,240	4,980	1,600,000	1.12	408
January, 1912					
Untreated	3,850	4,750	1,554,300	1.18	377
Treated	4,305	5,263	1,544,700	1.17	414

TABLE II. COMPRESSION PARALLEL TO GRAIN

Specimen	Elastic Limit lb. per sq.in.	Modulus of Elasticity lb. per sq.in.	Max. Load lb. per sq.in.	Deflection for 2,000 lb. per sq.in.
January, 1911				
Untreated	5,277	621,000	6,180	0.055
Treated	4,770	568,000	5,650	0.052
January, 1912				
Untreated	5,075	529,400	5,958	0.051
Treated	5,553	633,000	6,440	0.041

TABLE III. COMPRESSION PERPENDICULAR TO GRAIN

Specimen	Elastic Limit lb. per sq.in.	Load in lbs. per sq.in. for a deflection of $\frac{1}{16}$ in.	$\frac{1}{8}$ in.	$\frac{1}{4}$ in.
January, 1911				
Untreated	1,031	727	1,120	1,530
Treated	1,150	711	1,107	1,540
January, 1912				
Untreated	986	704	1,052	1,483
Treated	945	1,056	1,340	1,691

Shipbuilding in Japan—There are 239 shipbuilding yards in Japan, not including junk-building establishments. Of course, many of these yards are small, and the appliances still rather primitive. For the last year covered by available authentic statistics these yards turned out 77 steamers, of 24,479 tons, and 147 sailing vessels, of 11,097 tons. This record does not include a number of new steamers since completed or authorized, which tend to strengthen Japan's North American and European lines. All of Japan's leading steamship lines are preparing to build additional steamers for foreign service, mostly medium-sized freight and passenger craft. Japan's total shipping now includes 2545 steamers, of 1,233,909 gross tons; 6392 sailing vessels, of 414,720 gross tons; and, in addition, a large number of junks. Four steamers, having a gross tonnage of 15,817, were completed during the year under the law for encouraging shipbuilding. The subsidized steamship lines now number 24, which operate on most commercial routes throughout the world, except in the Atlantic Ocean. With the completion of the Panama Canal, Japanese steamers will probably visit the Atlantic seaboard, particularly in connection with the extensive raw-cotton freight traffic.—["Engineering," London].

*See also Eng. News, Mar. 24, 1910, p. 333, for article on strength of creosoted timber.

Future Progress in Irrigation

By Frederick H. Newell†

There are in the United States over fourteen million acres of lands cultivated by the aid of irrigation, and the crops produced on these lands have an annual value of over $300,000,000. Nevertheless a large proportion of the money invested in irrigation enterprises has been lost. Capital can no longer be secured for irrigation works carried on by private enterprise and millions of acres of lands to which water has been brought are lying uncultivated.

No man in the United States has a larger knowledge of the irrigation situation than Mr. Frederick H. Newell, Director of the U. S. Reclamation Service. The nation owes a great debt to Mr. Newell for the fidelity and ability with which he has carried on the great enterprise committed to his care. His opinion on the irrigation situation and on the directions in which progress should be made in order to proceed further with the work of converting arid desert areas into fertile farms carries great weight.

*Condensed from an address before the National Irrigation Congress, Salt Lake City, Oct. 1.

†Director, U. S. Reclamation Service, Washington, D. C.

What has been accomplished through the twenty years of study and discussion of this great subject of home making through the reclamation of arid lands by irrigation? It is impossible for us now to appreciate how little was known or cared about this subject, how few were the men who gathered here in Salt Lake City in September, 1891, to attract public attention to the needs and opportunities of the West.

A few enthusiasts at that time urged national irrigation, but most of the people interested believed that larger and more immediate results could be had by turning the remaining arid lands over to the several states in which they are located, as was done with the swamp and overflooded lands.

After many debates, extending through several successive annual meetings, the conclusion was finally reached that the remaining public land should be kept as the heritage of the nation, to be disposed of for the benefit of all rather than given directly to the state in which the land was situated. There was a well founded fear that the donation of the arid lands to the states would be followed by the same conditions as took place when the swamps and overflowed lands were donated, and that these lands would pass into the control of large corporate interests to be held for speculative profits, as was the case with the swamp lands.

When the Irrigation Congresses were begun all efforts in the way of reclamation were under private or corporate auspices, and the lack of financial success had resulted in practically stagnation of further effort. The most immediate result of the arousing of general interest in the subject was the passage of the so called Carey Act of Aug. 18, 1894. This for a time seemed to promise great results. It enabled the officials of each state to select lands for reclamation, the state being responsible for the carrying out of the work. It was assumed that each state would enter into suitable contracts, possibly furnishing some of the capital, at least carefully overseeing the construction, and by this public oversight virtually guaranteeing the success of the enterprise.

The anticipated results, however, did not follow as rapidly as expected. The states were slow in accepting the responsibilities, and for several years little was accomplished. It began to be appreciated that the state officers, loaded as they are with multitudinous duties, cannot give close and continued attention to details of this character. The states were not able or willing to finance the enterprises. Thus another period of partial stagnation followed and it appeared as though little more could be accomplished.

Meantime the friends of national irrigation had not been asleep. They urged that the Federal Government, the great land owner, had the power and the means of taking the initiative, and finally when bill after bill had been introduced in Congress, and favorably reported by committees, at length, on June 17, 1902, the Reclamation Act was passed definitely outlining a policy of federal development.

The entrance of the government upon this policy immediately created great interest in the whole subject of irrigation. When it began to be appreciated that the nation as a whole was actively taking up reclamation, many of the private and Carey Act enterprises which had been languishing took on new life.

Under the terms of the Reclamation Act, an organization was formed embracing some of the best engineers and experts available, and construction began, each detail being worked out in a manner suitable for works of permanent character. Thus there resulted a standard for private effort. The government could not properly continue the building of the temporary wooden structures, nor use the expedients which had been in vogue up to that time. Its designs must be with regard to the future. Thus it took the part of a pioneer in developing methods and structures such as are necessary for the permanent reclamation of the land. In short, it not only stimulated private enterprises, but set a standard in methods, one which has been followed in detail by all large enterprises.

The result is that, although the United States has actually reclaimed a relatively small part of the irrigable area, yet this small part has served as the incentive or model for a much larger area and will continue to do so as the operations are repeated and a higher degree of perfection reached with each new enterprise. The government, from the repetition and magnitude of its operations is able to benefit by its own experience, and each year add to the improvements in methods already made.

The Area Reclaimed—At the present time we have, according to the last census, a condition of irrigation development about as follows:

ACREAGE IRRIGATED IN 1909 CLASSIFIED BY TYPE OF ENTERPRISE

Individual and partnership enterprises	6,258,401
Coöperative enterprise	4,646,039
Commercial enterprise	1,444,806
Irrigation districts	533,142
Reclamation service	395,646
Carey Act	288,553
Indian service	172,712
Total	13,739,499

Individual and Partnership Enterprises, 6,258,401 *Acres*—These enterprises have the largest total acreage of any of the items enumerated, being nearly one-half of the irrigated area of the United States. They embrace the lands irrigated by individual farms and by neighbors acting together without formal organization. Most of the works which supply these lands are small and cheap, the structures having been built by the farmers themselves. Most of the early irrigation canals and distributaries were built in this way at the easiest places by individuals acting separately or joining together and carrying the developments to a point where larger amounts of capital were required.

Coöperative Enterprise, 4,646,039 *Acres*—When it became apparent that individual and partnership enterprises could not successfully handle the larger or more difficult pieces of work the farmers began to associate themselves, usually in some form of stock company, the stock of which was and is owned by the water users. In Arizona and New Mexico these coöperative enterprises are operated under laws governing "community" ditches. There is no hard and fast line between the partnership enterprises and these cooperative undertakings.

Commercial Enterprise, 1,444,806 *Acres*—Next in order of development and in difficulty of undertaking are the commercial enterprises, which stand third in the list, and which have reclaimed about 10% of the irrigated area. These include the organizations which have been formed to exploit the opportunities and to make a profit out of the sale of water rights or of lands. As a rule the easier localities for such work had already been taken by individual or coöperative enterprises. Thus many of the undertakings were found to be more difficult and expensive than anticipated, so that few, if any, have been financially successful to the investors, the profits, if any, going to the promoters of the enterprises.

Irrigation Districts, 533,142 *Acres*—Fourth in order of importance and extent of area irrigated are the irrigation districts which are semi-public corporations operating under state laws and empowered to issue bonds, and levy a tax for the purpose of obtaining funds for the purpose of construction, and for the operation and maintenance of irrigation works.

The irrigation district form of organization appears to offer probably the most favorable opportunity for the development of irrigation. It can be utilized, however, only where there is a basis of value to enable the sale of bonds at par. In an undeveloped country where the farm lands have not yet been brought to a high degree of productivity, there is absent this very necessary foundation for security and many proposed districts have been unable to sell the bonds and to raise a sufficient amount of money to execute the desired works.

Reclamation Act of 1902, 395,646 *Acres*—Fifth in order of importance of area irrigated are the results of activities under the Reclamation Act of June 17, 1902. Although only seven years had elapsed since the passage of the act it is shown by the census that an area of 395,646 acres was irrigated in 1909, a still larger area of land being ready for use. It is gratifying to note that in this short period such large results have been accomplished.

Carey Act of 1894, 288,553 *Acres*—Next in importance of results obtained comes the operation of the Carey Act of 1894, under which, in the 15 years there was irrigated 258,533 acres, over one-half of this being in Idaho, and about one-third in Wyoming. Many of the states have been slow in accepting this act, and in others there has not been a display of great energy on the part of the public officials in utilizing the opportunities thus offered. The principal disadvantage from the public standpoint from this act is that it encourages speculation in lands or a tenantry system, and does not enforce those requirements of settlement and cultivation of the soil which are so essential in the best development of the nation.

Indian Irrigation Works, 172,912 *Acres*—Last in our list of the classes of irrigation works are those being built by or under the direction of the Indian Service. These are to bring under irrigation large areas of valuable desert lands included within the Indian Reservations, and which have been, or are being allotted in part to the Indianas and the remainder being disposed of to the whites. The principal works are being executed by the Reclamation Service in the building of comprehensive systems such as those on the Blackfoot and Flathead Reservations in Montana, and the Gila Indian Reservation in Arizona.

Crop Production—The mere recital of acreage irrigated or prepared for irrigation does not, however, tell the whole story of present conditions. The real test is in the quantity and value of crops produced.

In round numbers the 13,739,499 acres reported as irrigated in 1909 are estimated to have produced crops valued at about $300,000,000. This sounds like a large sum, but if we consider that the average value of the crops is less than $25 per acre, this does not seem so large.

Taking the kinds of crops we find that alfalfa is by far the most valuable, as it includes over 30% of the total area crop and yields 28% of the total value of production of irrigated lands. Next in importance to alfalfa are the wild, salt or prairie grasses, being over 21% of the total area, but giving only 6.5% of the value. It is the inclusion of this large per cent. of the grasses in the average which brings down the crop values. Orchard fruits and grapes, relatively small in area, form but 3.2% of the irrigated area, but contribute 10% to the total crop values.

One of the striking points brought out by a discussion of the census returns is that the cereals in general are not a very profitable crop. While it is necessary in subduing the land to plant oats, wheat, barley, etc., the increased yield under irrigation does not usually justify the continued production. Farmers who are depending upon staple cereal crops, that is, those which are being raised in the humid regions, are not making the best use of their opportunities and are dropping behind.

A study of these figures comes as somewhat of a shock and surprise to those of us who know what large production is possible on farms intelligently irrigated and carefully handled.

The crucial point of the whole irrigation situation lies in this matter of average and total crop production. If the irrigable lands for which water has been provided at great expense are not utilized, the expenditure for irrigation cannot be recovered. If the irrigated lands are cultivated and the value of the product is not sufficient to yield a generous profit to the farmer, he cannot pay his debts. If the farmer from the sale of his crops, cannot meet his obligations, the investors furnishing the money cannot receive their interest when due and the whole fabric of credit and public confidence in irrigation works tumbles to the ground.

This is a serious condition which is now confronting us. The average crop production in the irrigated region is almost ridiculously small, compared to the opportunities. It is not creditable to the American farmer. When we consider that agriculture under irrigation means intensive farming and requires for success the application of brains as well as water, we are disappointed by the failure to reach higher yields. It must be recognized, however, that we are still in the pioneer stage, and that the average crop production is kept down by the fact that it includes returns from many new farms, handled by individuals not all of whom are really farmers.

If we could separate out the 25 or 30% or more of the farms which have been carefully handled and are being managed by experienced men, we would see that under irrigation the crop returns are very large. With the almost continuous daily sunshine of the arid West, and with adequate water supply, it is possible to obtain large returns per acre; but in taking the census of all the people we must include the unskilled with the skilled, and the incompetent as well as the efficient.

Causes of Small Crop Returns—In order that we may obtain better results in the future, we must consider carefully the causes of the small average crop return. These may be classified as follows:

1. New farms not yet completely developed.
2. Lack of skill and knowledge on the part of the farmer.
3. Excessive use of water.
4. Insufficient water supply.

New Fields—Each year sees a gradual increase of area brought under irrigation and cultivation, and as might be expected, the crop returns for these new areas are small. It requires considerable time to subdue the desert soil and put it in the condition of maximum crop production. The careful farmer levels the new fields in order to economize in the use of water and in the time required to apply it. In this leveling process patches of subsoil or less fertile soil are exposed and uniformity of the fields cannot always be had for some years. It is necessary before the best results can be obtained that a blanket of alfalfa be gradually spread over the lands, this being preceded sometimes by a crop of grain. The alfalfa is later turned under the surface, enriching the soil and getting it in condition

for profitable crop productions. This of necessity requires a few years; in the meantime the average value of the crops produced is kept down.

The agriculturists tell us that the needs of the West are not only for nitrates such as may be supplied by the cultivation of alfalfa, of clover or of members of the pea family, but in addition certain of the soils should have potash. There is usually an excess of sodium salts of one form or another and in some cases it is necessary to wash these out, but the potash salts are deficient in quantity. In the production of potatoes, for example, it is believed that there is more need of the potash than there is of the nitrates, especially those of the sodium compounds. This must be supplied to the new fields by using artificial fertilizers. They are quite expensive in the arid region and the pioneer farmer cannot always procure them.

Lack of Skill—This condition of subduing the soil is temporary, but a far more serious obstacle to general success is in the indifference or lack of appreciation of the farmer as to the necessity for continued careful cultivation, and for concentrating his energies upon a small farm. Most men are ambitious to own the lands bordering upon them and rate their success by the number of acres owned rather than by the crop production per acre. Few keep careful records, and appreciate at the end of the year that they would have had larger earnings from 40 acres well handled than from 80 acres carelessly tilled.

The figures from the localities where careful observations have been made show that within proper limits the smaller the irrigated farm the better the bank account of the farmer. The larger the farm the poorer the cultivation. Of course, there are exceptions to this as to any other broad statement, but in the mind of everyone is pictured the small carefully tilled farm of the successful irrigator, and the big weedy fields of the careless cultivator. Every acre in an irrigated region which is not being carefully handled is a detriment to the entire neighborhood. On a single neglected acre weeds may grow sufficient to seed down a whole section and to increase the labors of every neighbor for miles around.

Too Much Water—The most detrimental condition growing out of ignorance or indifference of the irrigator is that arising from the use of too much water. There is hardly a community which is not suffering from this. Thousands of acres of the best land in each irrigated locality are being ruined by alkali and by swamping due to the excessive use of water on neighboring or higher lands. Tens of thousands acres of these higher lands are being reduced in value by the slow but certain washing away of their fertility.

Experiments and observations have shown that the best crops are produced by the man who uses the smallest amount of water consistent with good plant growth. In times of relative drought the finest and most valuable crops have been had, because the quantity of water applied has been less and the care taken in handling the crops greater. This fact cannot be too strongly enforced. It is human nature to demand and to apply to the land all the water to which the owner believes he is entitled. There is a vaguely defined fear that if he does not get his share he may lose it. It is not possible to prove to him that his own soil is being injured unless he happens to be on the low ground where he is swamped out by his more or less distant neighbor.

Drainage and Alkali—We are coming to appreciate that drainage for large reclamation projects is as essential as irrigation itself, and that the drainage system must be outlined while the distributing works are being built. It has been found to be impossible to plan out in advance the drainage system with as thorough knowledge of the conditions to be met as is the case with irrigation distributaries. This is because of the fact that while the distributaries are on the surface and meet visible surface conditions, the drains must be provided to overcome subsurface or underground difficulties, many of which cannot be foreseen.

The drainage system of a Reclamation Act project is as necessary for its success as is a sewer for a town. The excess or waste waters from the irrigated fields must be taken away in order to prevent harmful accumulation of alkali. The extent of drainage can, of course, be greatly reduced by proper use and application of irrigation water, but even under the best handling there will always be need for drainage.

Professional Pioneers—The small average crop value under irrigation has been attributed largely to the presence on the projects of a class of men who have been termed by their neighbors "professional pioneers." They are men who have learned that more money is to be made at first out of Western farm lands by the unearned increase in value than there is through the hard work of crop production. A man of this class obtains by homestead entry or purchase the control of a good farm. Not having the capital to develop this or the energy or intent to make a permanent home, he lives from hand to mouth during the time in which he hopes that the land will double or treble in value.

As soon as it is realized that the land values cannot be shoved up higher, then these professional pioneers begin to disappear, and the real farmer whose ambition is to make a home for his family begins to appear more prominent. As long, however, as there is the promise of wealth through holding a piece of land rather than utilizing it, so long will there be indifference, leading to small crop production.

Ignorance of Larger Facts—The greatest obstacle to the rational development of the West through irrigation is due to ignorance of the essential facts.

Ignorance of the real cost and value of irrigation is leading to unfair and destructive criticism of the work of the Reclamation Service and of the other agencies tending to upbuild the West. The average man hears that the works being built by private capital are more economically constructed. If he takes the trouble to ascertain the facts he will find that the work being done by the government, when compared with similar work elsewhere, is better done and less expensive. These are facts which can be demonstrated to any man who cares to take the trouble to ascertain them; but it is so much easier to draw comparisons with assumed conditions than it is to study the facts as they exist.

The Poor Man's Opportunity—The Reclamation Act has been called the poor man's opportunity. Under it thousands of men have been able to secure a home and have reasonable hopes of future competence. It offers an opportunity to the great body of American citizens who, while not having available any considerable amount of money, yet are rich in energy, in a growing family, and in everything which tends to the success wherever such an opportunity is presented.

No rich man would consider going into a pioneer community and endeavoring to cultivate intensively a small area of land. On the other hand, it is not the poor or shiftless farmer's opportunity. The latter should not attempt this highly specialized and difficult operation.

Unearned Increment of Value—One of the great obstacles is the high price of raw land. The expenditure of the Reclamation Fund or even the proposition to expend any considerable portion in a community creates a rapid rise in prices, not only of raw land which may be actually irrigated but also of surrounding lands, especially town lots. This increase in prices asked for agricultural and residence property comes about not through the activity of the owners or through any expenditure on their part, but is what is usually termed the unearned increment. It has been the basis of many private fortunes in this rapidly growing country.

The best condition of the community is that where this unearned increment goes to the small land owner who is living upon his farm, cultivating and improving it by his labor, and who thus receives not only the reward of his toil but a bonus stimulating him to further exertions.

The worst condition is where the unearned increment goes not to the men

who have each labored for it, but to some single individual or corporation, who by virtue of chance shrewdness or grant from the state is able to control a considerable tract of land and to extort from the man seeking a home, this increase in price which has not been earned.

This is unfortunately the case in most of the irrigation enterprises in the West, whether financed by corporate or public capital. The unearned increment of value has gone in large part, not to the individual pioneer or settler who by energy, skill and thrift has subdued the soil, but to some individual who has made little exertion beyond sitting quietly and holding the land for a rise in value.

Unearned Increment—A comparison of the figures obtained by the investigation of the Senate Committee and of the Board of Army Engineers on the various projects shows that before construction of the works by the government the lands without water were worth on an average not much more than $5 per acre. This was mainly prospective value, and may be said to be about enough to cover the cost of surveying and conveyancing. After the works were initiated or completed the land values, exclusive of the charge for water, have as a rule jumped rapidly to $50 or even $100 or more per acre, without improvements. The unearned increment of value has thus been approximately a thousand per cent. It is this heavy charge which is at the bottom of most of the complaints which are being received with reference to the difficulties of the farmer.

Irrigation Bonds—It is obvious that further irrigation development on any considerable scale, outside of that done by the government, must come about through the use of funds raised from the disposal of bonds. Therefore we must look with especial care to everything which affects the value of these bonds, and the opportunity to dispose of them. The value of an irrigation bond is dependent, *first,* upon the security, *second,* upon the interest yielded, and *third,* upon the marketability.

It is fully appreciated by all that there must be unquestioned security behind any bond to give it value, and that the bond itself must produce a sufficient annual income to the owner to be attractive. The third condition, that of marketability, is frequently overlooked because it is assumed that if a bond is good and if it returns a fair rate of interest anyone will be willing to buy it. On the contrary, if through any cause there arises a lack of confidence, it is not possible for any one class of bonds to be quickly disposed of in emergencies.

For example, there may be two classes of bonds on the market, one, municipal bonds, the other, irrigation. As a matter of fact, the municipal bonds may have less security behind them and less rate of interest, but they are more readily disposed of simply because people are accustomed to handling them. The methods of enforcing the obligation have been established through years of judicial decisions. There are few unsettled questions. On the other hand, irrigation bonds in general are regarded with suspicion, large losses have been had through holding them. The holder of an irrigation bond no matter how good does have considerable difficulty in disposing of it in times of stringency. The true value may not impress the prospective buyer so much as the question of convertibility into cash if unforeseen contingencies arise.

Security Back of the Bond—The security behind an irrigation bond is dependent upon several different conditions, not all of which are well understood. These may be summed up under the following heads:

(1) Adequate water supply.
(2) Complete legal protection of the supply.
(3) Effective construction of the works.
(4) Fertility of the soil and favorable climatic conditions.
(5) Accessibility to the markets.
(6) Good will of the farmer.
(7) Adequate water supply.

1. Many of the original irrigation projects were initiated without any knowledge of the water supply and works were built largely in hopes that water might be had after these were completed.

2. Even though there existed on the ground an apparently adequate supply of water, it has been found that the state laws and court decisions have not always protected the claimant to the full amount of water needed for his undertaking. In some of the states it has been asserted that more money has been spent in litigation over water rights than in building the works.

3. Many of the earlier irrigation projects were built very cheaply with temporary wooden structures, so that after they had been in use for a few years, it became necessary to practically rebuild the system and to call upon the owners for continual expenditure far above that anticipated, thus cutting down their profits and preventing payment of interest on the investment.

We have now reached a point, however, where irrigation construction is better understood, and is being planned with reference to permanence and economy of operation.

4. As a rule, throughout the arid region the soils are suitable for crop production and if not injured by excess of water rendering them swampy or alkaline, the soils continue to produce bountiful crops, especially when well fertilized, and crops rotated, so that relatively few failures have occurred from this cause.

5. Markets have been developed as a rule, and railroad lines established coincident with the bringing into cultivation of a considerable area of land. During the first few years, however, it has frequently been difficult for the farmers to dispose of their crops. Until coöperative associations have been formed and experience gained, there is apt to be loss of effort resulting in the farmer's not being able to make his payments, although his crops were apparently bountiful.

6. The attitude of the farmer himself is one of the most important matters and one which has been frequently overlooked in considering the value of irrigation bonds and securities. Many a promising project has been brought to ruin by ignoring the most important factor of all, namely, the farmer. Upon him the entire structure rests; he must dig out of the soil the profits which go to reimburse the investor.

It takes a long time to establish a paying farm. The soil must be subdued and in many parts of the arid region fertilizers must be supplied, especially nitrates. These are had generally through cultivation of alfalfa. Sometimes mineral salts such as potash must be added. The surface must be leveled to produce economy of labor and water. Experience must be obtained through several years of effort, to know the best or most profitable crops, these being determined not only by the soil and climate but by the market.

The farmer is apt to be discouraged during these years of experimentation. He cannot at first always make a living for his family and cannot pay the upkeep of the irrigation system, much less continue the payments due to the investors. If to his natural discouragements are added a feeling that he is being oppressed by a soulless corporation, we have a tendency to neglect and to resort to shiftless methods, delaying still further the realization of intensive agriculture.

What Must We Do To Encourage Further Development?—The question is forced upon our attention as to what should be done by this organization as a whole, and by its individual members to lift the irrigation cause out of its present stagnation, and to bring about a larger and better use of the resources of the West.

In order to extend the irrigated areas, money must be had. All of the easy projects have been taken. The complications of vested rights are such that no further extension can be made without large expenditures of time and money in acquiring these rights and extinguishing some of them.

Investors will no longer take hold of

the work for an investment. No money is available and no money can now be raised for the initiation of large projects because practically every dollar put into the stock of these corporate enterprises in the past has been lost. The only man who is at all interested is the promoter. He has hope of making a quick turn and of securing the promoters' profits. Encouragement of this kind of enterprise is contrary to sound public policy. It causes loss both to the real investors and to the farming community.

We cannot shut our eyes to the fact that every step taken is surrounded by difficulties, but at the same time we should not be discouraged or alarmed over these difficulties. The work so far accomplished by the Reclamation Service shows that the obstacles of vested rights and of complicated conditions of water supply can be overcome by carefully working out the problems.

Methods of Future Growth—There are two ways in which adequate funds may be had without involving the risk of private or corporate speculation.

First: Under the terms of wise and well enforced district laws.

Second: Under laws to be made by the Federal Goverment.

District Organizations—In many respects the organization of irrigation districts and the construction of works by the land owners themselves using money borrowed upon the security of their farms, is, or should be, the ideal condition. The first obstacle arises from the fact that many of the desirable localities do not have sufficient basis of value to enable loans to be secured, that is to say, the lands of the district are not in themselves adequate security. The men making the loan are not convinced that the money will be expended in such way as to increase the security.

Another objection lies in the fact that the irrigation districts have not always been wisely managed. In case of each of the districts the work is new, the men in charge have never handled large affairs of this kind. Like all beginners they invariably make many mistakes, often expensive, or waste a large part of the available funds before they learn how to conduct affairs effectively. In this respect they are at great disadvantage as compared with the Federal organization which performs the same work over and over again, utilizing the services of men who have had years of experience in these operations.

In spite of these drawbacks we believe that the states should try to improve and perfect laws governing irrigation districts, to encourage the development of these, and the payment of the cost of irrigation through taxation upon the lands generally.

It is appreciated that it will require years of patient effort to restore the confidence of the public in these irrigation district securities. Having once been disappointed, capital, notoriously timid, will not risk investment in these bonds until the districts already organized are actually keeping up the interest on the securities, and are refunding the principal.

There is now the ever present apprehension that, although the irrigation-district securities on the surface appear to be good, yet there may be some defect discovered or suit instituted. This is based upon the general knowledge that many of the securities have been issued through collusion to evade the intent of the law. It is well known that in most states securities of this kind, bearing interest at about 5%, are required to be issued at par. It is equally well known that this cannot be done and that the law is evaded by a clever combination between the contractor who builds the works and the district officials, by which the contractor receiving the securities at par bids an exorbitant amount for the work and really obtains the bonds at about 70% of their face value.

Where a transaction of this kind is so well known, there is always danger that some aggrieved party will call into question the validity of the transaction. While from a legal standpoint, there may be no probability of actual trouble, yet the investor, knowing the condition, is naturally timid about buying into a lawsuit, even though it may be capable of easy defense.

State Advances or Guarantees—The question has been asked why should not the individual states loan funds or advance them credit for the construction of irrigation works. This was the theory upon which the Carey Act was based, namely, that each state would take up the work of reclamation on a business basis and push it to early completion. As a matter of fact, however, the states have either not had the money available or have not deemed it wise to appropriate funds for the direct construction largely because it has not been practicable to provide adequate machinery for the purpose.

In our present degree of development of state governments there is frequent change of policy and personnel, so that it has been found difficult for a body of men to devote their exclusive time and energies to state work of this kind. The average duration in office of state officials rarely extends beyond two or four years. No large system of irrigation can be planned and constructed during this period. The result is that with each change of administration there are such radical changes in policy that much of the value of the work is lost.

Although it is apparently impracticable for the states to advance money in the actual construction of reclaimed works, as is being done by the Federal Government, there is, however, a great opportunity for each state to throw such safeguards around the operations as to practically amount to a guarantee of the investment. Various efforts have been made, particularly in the organization of irrigation districts having a taxing power. These laws have in the main been so crude as to discourage effort, but beyond this discouragement we should see that the defects are not in the theory but in the incomplete working out of it.

The first or most notable district laws were those of California, the principal one being the so called Wright Act, under which nearly 50 districts were formed, about half of which issued bonds aggregating millions of dollars, and of these bonds a few now have value. Others have been retired at 50c. or less on the dollar, and some even have been repudiated.

The disasters of this history have been greatly magnified. The few instances of success attest the fact that under proper legislation a district act can be made successful.

The principal source of weakness is that the state has either exercised no supervision or has entrusted this to officials not qualified by personal knowledge and who are overloaded with other duties. It is too much to expect that a state official can learn an entirely new business and at the same time give any considerable thought or exercise wise discretion in a matter which is not wholly clear even to the man who has devoted his life to the subject.

For success the state should secure proper oversight of the irrigation districts through a body of men who can devote their time continuously to the subject and can make it a life work, in the same way that the manager of the railroad or any large industrial corporation makes such an undertaking his life's work. Then we can hope for the effective carrying out of an irrigation district.

The success attained under the Federal Government comes from this condition of continuity of purpose of men employed to push forward the large work as their sole and only occupation. Such men can make this work a profession and can devote the best energies of their lives to it, as they would do if working for a corporation. There appears to be no reason why the state as well as the Federal Government should not be able to secure effective work by able men if it will select them without reference to politics and for ability alone and impose upon them the same responsibilities and opportunities given by any large corporation.

Federal Activities—We must look to federal activities to lead the way. The results already shown in the ten years of operations under the Reclamation Act justify the belief that the work is being executed economically and effectively, and that larger results with a given expenditure are being obtained under

systematic methods than have been had under any of the other attempts. If this is the case, the public interest demands that the work be pushed forward on the basis of the experience already attained, and that funds available should be increased from time to time in proportion as the lands reclaimed are being put to their best uses.

The Reclamation Fund derived from the disposal of the public lands has amounted up to June 30, 1912, to $70,000,000. In addition there has been made available $20,000,000 by the loan of June 25, 1910. Water has already been provided for over 1,000,000 acres, of which about one-half is now in crop and works have been from 60 to 90 per cent. completed, which will enable water to be brought to a total of about 3,000,000 acres. This total is only about a tenth of what should be undertaken. We should have available for investment a still larger sum supplementing the returns which are coming in.

Returns to the Reclamation Fund—The test of success of the Reclamation Act is quickly shown in the returns received from the investment of the money. These returns are coming in steadily and the public have come to accept this return as an established fact. When the act was passed many predictions were made in Congress and elsewhere that not a dollar of the Reclamation Fund would come back. From time to time ambitious men in the Western states have made more or less definite promises that they could and would secure relief from repayment. Fortunately such promises have not been taken very seriously and will not be while it is appreciated that every dollar unpaid means deprivation to others of the use of the money. This amount is to be reinvested for the public good. Every dollar when repaid is used over and over again for the public welfare, and if not paid the endless chain of public benefit is broken.

It is admitted that the returns are not as large or as immediate as anticipated. This is due to the fact that the crop returns in the earlier years are necessarily small. A longer time than anticipated must be taken in subduing the soil, in raising good crops and in securing markets. This means simply that we must provide in our plans for smaller returns at first and instead of being discouraged by this make better and larger plans for the future.

Residence Requirements—The residence requirement of the Reclamation Act is one of the chief elements of success. It is really the fundamental reason for the government undertaking the work. It insures to the government and to the people the success of the act in that it insures a resident land-owning citizenship instead of a speculative, non-resident, landlordism. There have been many complaints because of the hardships resulting from enforcing residence, but careful study of these show that most of the complaints are from the very men who should be excluded from the benefit of the act, namely, the men who are not real farmers, but who desire to secure a small piece of land in which to invest their savings with a view to hiring a tenant and gradually developing a good property. This is a laudable ambition, but why should not the tenant himself be given the opportunity to become a land-owning citizen? If he lives upon the land, and makes it valuable by his efforts and his presence upon it, why should not he gain the reward of the unearned increment of value?

Conclusions—In reviewing the present conditions and in considering what we may do to improve these, it is appreciated that we are now facing one of the great opportunities and problems of national development. As has been shown by the figures of the census and the statements of the Department of Agriculture, there are now millions of acres for which water has been provided but which are not as yet being cultivated. There are other millions of acres under irrigation from which the crop returns are not adequate to pay for the cost of water and labor of cultivation. The lands which are being cultivated should be brought to a higher condition of productivity, they should yield larger crop returns in order to enable the farmer to support his family and to pay his debts, thus restoring confidence in the minds of investors in irrigation securities. In other words, we must put behind the irrigation bonds and similar securities the real values which come from careful and thorough cultivation of the soil.

Having demonstrated to the world that the arid regions can produce large crops per acre, we must encourage the systematic search for high-grade farmers for the lands which are being reclaimed. There are throughout the East thousands of men who are eager to know of the opportunities and who have the thrift and energy to make a success. We should try to reach these men and call to their attention the opportunities in the arid region. To do this, we must present to them the facts such that when they come here, they will not be disappointed. One man who does not make a success will do more to injure the development of the country than a dozen who do succeed.

We must consider well those forces which once set in motion stimulate development along right lines. It is obvious that this must come about through the demonstration of the larger use of the lands already reclaimed, and by the success of the farmer who can and will cultivate the ground intelligently and who can and will produce crops sufficiently large to bring about returns to the investment already made.

When this is done, when we have secured on an average the excellent results which men everywhere are showing can be had under irrigation, then there will be no hesitation in getting funds enough to bring about the development of larger areas.

The reward of all of this effort is not merely in the material prosperity of the individual and of the community, but more than this, in the steady growth and strengthening of those democratic institutions which are vital in the perpetuation of our government.

The tendencies of the time are toward the concentration of wealth and power in the hands of the few through the natural growth of great corporations. With the increase of each means of communication and with the study of economics of production and distribution, there is a continual reduction of individual competition and increase of union among men to eliminate waste and bring about larger returns.

Thus, we have unions and trusts, and all of those combinations of labor and capital which, desirable in themselves when controlled, are the natural outgrowth of our present degree of civilization. There are certain dangers to the body politic in these combinations, unless at the same time, we develop methods of control. It is this question of national and state control which now confronts us on every hand.

The one great safeguard in all of these dangers is the fact that there still exists a considerable body of independent citizens, owning and living upon their farms and who have always formed the substantial basis of free institutions. It is peculiarly the case that agriculture, especially on an intensive scale, is not capable of being organized into trusts and handled on a large scale by any one man or group of men. The products may be but the operations cannot. It is, therefore, incumbent upon us as citizens to do all in our power to extend the number of independent land-owning citizens and to add to the foundations of the nation by increasing the opportunities for homes of self-supporting citizenship.

Granulated Cork Sheets and Tiles are being used for insulation in cold-storage plants according to London "Engineering," Nov. 8, 1912. The particular material in question is made from granulated cork, slightly compressed and baked to give it required form. No additional binding material whatever is used, the natural gum or resin of the cork being sufficient to cause the particles to adhere. The sheets and tiles are claimed to form a resilient, noiseless, non-absorbant, nonslippery floor, which is also noninflammable, acid proof, and "practically everlasting." The material, it is claimed, has excellent electrical insulating properties, so that it is suitable for covering the floors of switchboards, galleries, and other places where it is desired to minimize the danger from electric shock.

A New Principle in the Design of High-Vacuum Pumps

A pump for economically producing the high degree of exhaustion needed for Roentgen-ray apparatus and for metal-filament lamps has been designed by Prof. W. Gaede, of Germany, employing radically new applications of apparently abstract scientific knowledge. The highest degree of vacuum yet recorded has been secured with this pump and in minimum time; yet there is a mechanically free and open passage from intake to exhaust of the machine. The invention is described in the London *Electrician*," of Oct. 18, 1912, from which these facts are extracted.

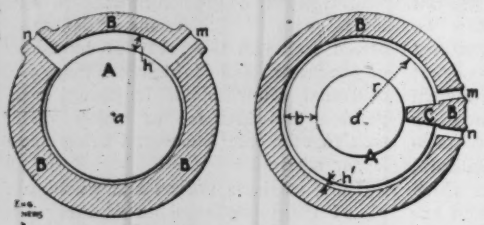


FIG. 1. DIAGRAM ILLUSTRATING PRINCIPLE OF GAEDE'S VACUUM PUMP

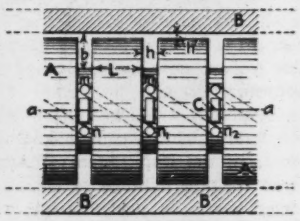


FIG. 2. ROTOR AND CASING OF THE GAEDE PUMP

The ideas involved were developed during experiments of the designer in the flow of gases through tubes. The earlier investigators had assumed that, with low pressures, gas molecules were thrown back from the tube walls independently of the angle of incidence so that with a difference of pressure between the two ends (gas molecules heaped at one end more than at the other), as many molecules were thrown to the forward end as were thrown backward. Prof. Gaede found that this was true only for gas pressures below 0.001 mm. Above that figure, a gas film formed on the walls and the molecules were reflected preferentially normal to the wall irregularities which they hit—that is, back toward the direction from which they came. Because of this action of the gas film, the amount of gas flowing through a tube in unit times decreases and the friction between wall and gas increases. In computing the gas friction between moving surfaces it was found that pressure forces appeared which could be applied to the practical design of an air pump for high vacua.

The scheme is shown simplified in Fig. 1 and the application in Figs. 2 and 3. In Fig. 1, *A* is a cylinder rotatable about its axis and inclosed within a casing *B*. In the casing there is milled out a groove extending from the port *n* to port *m* and having a depth *h*. If *A* rotates clockwise, the air in the groove will, owing to gas friction, be carried from *n* to *m*. The pressure difference between *n* and *m* is observable with a manometer and is proportional to the speed of rotation and the viscosity of the gas. On exhausting the casing, the pressure difference between *m* and *n* remains constant in spite of the resulting gas rarefaction because the viscosity is independent of the pressure. If the difference at atmospheric pressure is 760 mm. at *m* and 750 mm. at *n*, then on exhausting the air in the casing to 200 mm. at *m* a figure of 190 mm. is found at *n*. On further reduction to 50 mm. at *M* there is a value of 40 mm. at *n*. If the pressure at *m* was reduced to 10 mm., then the pressure at *n* should be zero if the relation held and an absolute vacuum would be obtained. But the rule becomes invalid at such low pressures.

At the very lowest pressures, the ratio of the pressures at *m* and *n* is independent of the degree of exhaustion. At pressures below 0.001 mm. the gas film disappears and the gas molecules are diffusely reflected from the surfaces independently of the angle of incidence. The surface of the cylinder may be pictured as shooting out molecules from it in all directions with a certain definite velocity (the natural molecular velocity) depending on the gas. When the cylinder surface moves with a velocity greater than the molecular velocity, then in the groove *h* the molecules shot off from the cylinder in the direction *n* to *m* will have a velocity greater than twice the molecular velocity and no molecules at all can travel backward in the direction *m* to *n*. As a result, at *n* is a region impoverished of gas molecules—a vacuum. Thus while the pump is commercially valueless at atmospheric pressure, it gives notable results when used in conjunction with an auxiliary exhauster.

In the actual construction (Fig. 2) the cylinder *A* is given grooves of a depth *b* and a width *h*. The projection *C* attached to the casing *B* extends down into the groove. The general appearance of this type as made by E. Leybold's Successors, of Cologne, Germany, is shown in Fig. 3. The pump is belt-driven by a ⅓-hp. electric motor, but the belt drives a separate shaft to which the pump rotor is flexibly coupled so as to relieve the bearings. The pump works normally at 8000 r.p.m. The cylinder does not touch the casing at any point, and the spindle is supported in the bearings by an oil ring. Nets are placed in the suction tubes to prevent the entrance of foreign bodies. Penetration of oil from the bearings into the exhausted casings is prevented by a special packing; for this to be operative, it is necessary, in starting up, to let the pump run up to speed and then to connect with the auxiliary pump. In stopping, the auxiliary must first be disconnected and then the main pump. All this can be done automatically by motor starters. A large pipe is provided for connection to the apparatus to be exhausted; the small nozzle is for connection to the auxiliary pump.

Several machines of this type have been tested by the designer with average results shown in the following table.

R.p.m.	Mm. auxiliary exhaust	Mm. final exhaust
4,000	20.0	3.00
4,000	10.0	0.08
4,000	1.0	0.0003
4,000	0.1	0.00003
6,200	20.0	0.08
6,200	10.0	0.002
6,200	1.0	0.00005
6,200	0.1	0.00001
8,200	20.0	0.005
8,200	10.0	0.0005
8,200	1.0	0.00002
8,200	0.1	0.00000*

*Not readable.

Special tests at different speeds are shown in a second table. In these tests, the hitherto unattained pressure of 2×10^{-6} mm. was measured.

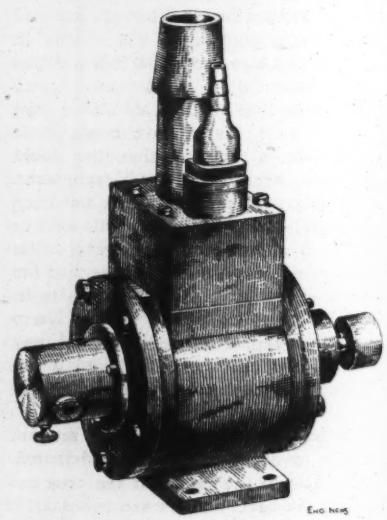


FIG. 3. THE GAEDE HIGH-VACUUM PUMP ASSEMBLED

(E. Leybold's Successors, Cologne, Germany.)

R.p.m.	Mm. Auxiliary Exhaust	Mm. Final Exhaust
2,500	0.05	0.0003
6,000	0.05	0.00002
12,000	20.00	0.0003
12,000	10.00	0.00003
12,000	1.00	0.000005
12,000	0.05	0.0000002

Since the action of the pump depends upon the direct influencing of molecular motion, it was expected that the pump would not only draw off gases but vapors also, in contra-distinction to hitherto employed air pumps. This is confirmed in experiments which have shown that there was no need of employing phosphorus

pentoxide or other drying agents, or of of freezing out the vapors by immersing in cooling vessels filled with liquid air.

Workingmen's Houses at Messina and Reggio, Italy

The earthquake which laid waste the northeast point of the Island of Sicily in December, 1908, completely destroyed all of the buildings at Reggio and Messina in which the Italian State Rys. housed a large force of workmen and an extensive office, warehouse and shop equipment. After the disaster the administration provided a number of temporary buildings pending an investigation into the proper construction to be used in earthquake countries, and has but recently completed the permanent structures which were designed as a result of that investigation. Stability was the prime consideration in the study of the new buildings, but good sanitation and hygienic living conditions also governed the design of that part of the new work which is devoted to residences.

While the resulting buildings undoubtedly satisfy the aforementioned requirements, they do not qualify from an esthetic standpoint. The view which we reproduce in Fig. 1, a portion of the railway employees' quarters at Reggio, hardly accords with the ideas for an artistic group of dwellings which some English and American architects and city planners are exploiting. Art in Italy seems to be mainly historical, or at least, too important to descend to so material an object as a workingman's house. On the other hand the houses are eminently practical, clean, airy and fairly roomy, which are more important to their inhabitants than decoration or picturesque arrangement.

Three types of buildings have been developed for railway purposes, two for one-story and one for two-story buildings, and all especially designed to be earthquake resisting. The one-story houses are of the general exterior type shown in Fig. 1 and are either of stucco or wire-mesh nailed to wood framing or brick facing tied in by wire to wood framing. In all cases the framing is thoroughly tied together and cross-braced and founded on concrete base-walls, so that the house makes a structural whole capable of resisting the twisting strains resulting from earthquake motion. Furthermore, the houses are isolated in two- to four-room groups so that there can be no progressive failure or conflagration danger.

FIG. 1. NOT A GARDEN CITY

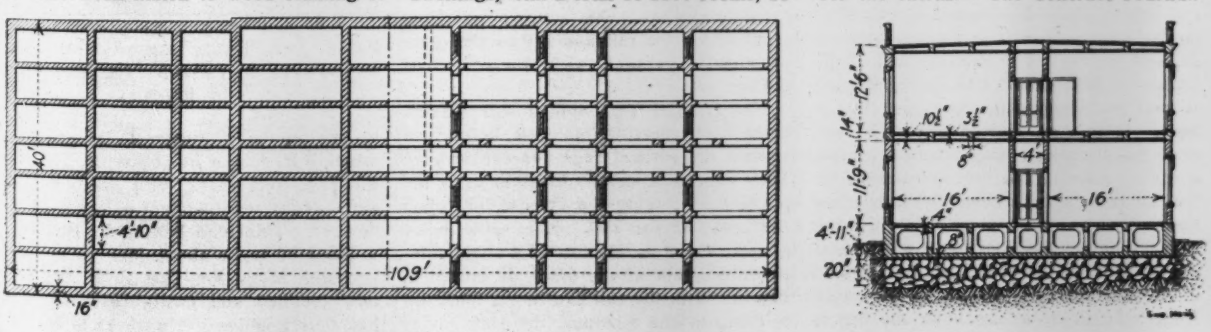
(Workingmen's Houses for Italian State Railways at Reggio, Italy, to Replace Those Destroyed in 1908 Earthquake.)

The reinforced-concrete houses are two stories high and are built in long rows, containing about 30 rooms in groups of three- and four-room apartments. A cross-section through the short side of such a building is shown in Fig. 2. The structure is of typical reinforced-concrete design, but is novel in the special earthquake-proof foundations. These, it will be noted, consist of a floor slab on beams resting on a rock-filled base and extending in both directions. They are hollowed out as shown to gain weight. Upon this "raft" the house proper is built as an integral structure.

In Reggio and Messina there have been built some five hundred of these dwellings, with a total of 2300 rooms, besides a number of warehouses, shops and offices of similar design. The cost has been about $1.30 per sq.ft. of floor area for the one-story houses and $3 per sq.ft. of floor area for the two-story buildings. About $3,000,000 is to be spent by the government railways in the total equipment and construction of these settlements, which sum covers the water and sewer systems to which each house is connected.

An article describing this work, by Fausto Lolli, of the Italian State Rys., appears in the *Rivista Tecnica delle Ferrovie Italiane*, October, 1912.

Self-sacrificing Ancient Contractors—In the course of a lecture on the marble used in Greek, Roman and Byzantine buildings, delivered before the members of the Architectural Association in England, by J. A. Marshal, mention was made of the Temple of Apollo at Delphi, built 530 B. C. The lecturer remarked that it was agreed that the temple should be built entirely of local limestone, but according to Herodotus the contractors won a reputation by using Parian marble for the columns of the facade, and declined to make any claim for the extras.—"The Contract Journal."



PLAN SECTIONAL ELEVATION

FIG. 2. DETAILS OF CONCRETE EARTHQUAKE-RESISTING HOUSE, MESSINA, ITALY

Rail Anchors or Anti-Creepers

Devices of different kinds to prevent the creeping of rails upon the ties were described in our issues of June 27 and Sept. 5 of the present year. We describe herewith two other forms of rail-anchors or anti-creepers now in use. They are of different types, but each effects its hold on the rail by a wedging action induced by the wedge shape of the rail base and the jaw of the anchor. As the longitudinal force is exerted in the rail it tends to slew or rotate the anchor, and as this is held firmly on one side, the jaw on the other side tends to wedge further upon the rail base and thus increase its

FIG. 1. THE "POSITIVE" RAIL ANCHOR TO PREVENT CREEPING OF RAILS ON THE TRACK

hold. In each case the anchor consists of a single piece of malleable iron. Under test, the rail-anchor showed a resisting strength of 8 to 14 tons before failure, while the anchor tie-plate showed a resistance of 29 tons. These two devices were invented and patented by Benjamin B. Betts, Supervisor of Bridges and Buildings of the Terminal Railroad Association, St. Louis, Mo., and are in extensive use on the St. Louis terminal lines. They are manufactured by the Positive Rail Anchor Co., of Louisville, Ky.

RAIL ANCHOR

The Positive rail-anchor consists of a malleable-iron casting of the form shown in Fig. 1, and the method of application is illustrated in Fig. 2. The locking jaw is first fitted to the rail base and driven up with a light hammer until the back of the jaw is in contact with the edge of the rail. The opposite end of the anchor is then raised and swung around so that the wedging jaw engages the rail base. It is then shifted along the rail until the abutting foot is in close contact with the side of the tie, and the wedging jaw is then driven forward with a few light blows until it is set firmly on the rail. Finally, the locking lug is hammered down so as to lie against the side of the rail base, the jaw being supported from beneath by a bar while the lug is being bent. This fixes the anchor immovably upon the rail. If it is desired to remove the anchor, this lug is sprung back to its original position by means of a chisel or spike; then the wedging jaw is driven back from the tie until the other jaw can be driven so far on the rail that the wedging jaw can drop clear of the rail base. Only a light hammer is used.

THE ANCHOR TIE-PLATE

The Betts anti-creeper tie-plate is a malleable casting of the form shown in Fig. 3, having wedge jaws and spike holes at diagonally opposite corners. The thrust of the rail causes the plate to rotate slightly upon one spike as a pivot, thus forcing the jaws farther up the inclined face of the rail base and so increasing the holding power. While the Positive anchor, previously described, prevents creeping in one direction only, the Betts anti-creeper prevents creeping in either direction, besides acting as a tie-plate and as a rail brace owing to its width and its hold upon the rail base.

FIG. 2. METHOD OF APPLYING THE RAIL ANCHOR

In applying this device the edge of one jaw is fitted over the edge of the rail base and the plate rotated until the other jaw is in line with the rail base; then the plate is raised and slightly rotated to bring both jaws in light engagement upon the rail. The plate is then slipped along the rail until it is in place upon the tie, when it is again slightly rotated by hammering upon its edge at the point indicated in the cut. This wedges both jaws securely on the rail and brings the plate practically parallel with the edge of the tie.

Finally, the two spikes are driven, being set carefully in the holes and against the vertical edge nearest the jaw. They should be driven so as to draw the plate, thus forcing the jaws tightly upon the base of the rail. The spike holes are so shaped as to allow of a slight rotative movement of the plate, as shown in Fig. 3. With the rail exerting a tendency to creep in one direction, the plate pivots on one spike; if the creeping is reversed, the plate pivots in the opposite direction on the other spike. In this way, the device is specially adapted for use on single track, which would require a double set of anchors of the Positive type, previously described.

USE OF THE RAIL ANCHORS

The Terminal Railroad Association, St. Louis, informs us that it has used the Positive rail-anchor to a very considerable extent, and is just beginning to use the anchor tie-plate. While no device of this kind is so effective as to do its work without any attention, it is considered that these devices are fully as effective as, if not more effective than, any other form of anti-creeper. In the summer of 1911 the Atchison, Topeka & Santa Fé R.R. applied (on its Eastern Grand Division) one lot of 41,250 Positive rail anchors, which were carefully inspected last spring by the makers' inspectors, who reported that they found "only 201 of them slightly loose, and all of these were tightened and are now in service." In view of the severity of last winter it is thought that this is an excellent showing. The A., T. & S. F. R.R. also made a test of over a year on 1000 of the Betts anchor tie-plates and since them has purchased 37,500 of them, 25,000 going to the Eastern Grand Division, and 12,500 to the Gulf, Colorado & Santa Fé Division.

Several thousand of the rail anchors and the anti-creeper tie-plates have been

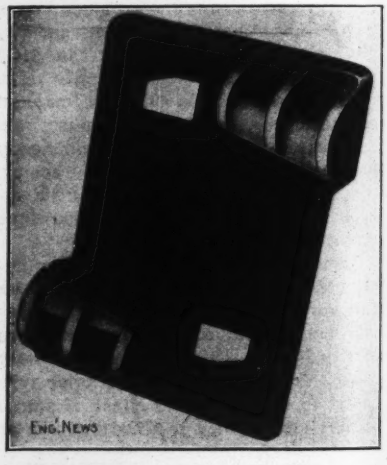


FIG. 3. THE "BETTS" ANTI-CREEPER TIE-PLATE TO PREVENT CREEPING OF RAILS

in use on the Kentucky & Indiana Terminal R.R. tracks in Louisville, Ky., for the past four years, with practically no expense for readjustment of either of the devices. This road has on its Belt Line a piece of track about four miles long, laid with 85-lb. Am. Soc. C. E. rail on a new roadbed and newly ballasted; this has four Positive rail anchors to the rail length (eight to the panel) on straight track, and four anchor tie-plates to the

rail length (eight to the panel) on curves. The above track constitutes the southbound main track, the traffic being all in one direction. No expense has been experienced for readjustment since this track was completed and the anchors and plates were applied (in May, 1910), and not one tie has been skewed or moved out of its original bed. On this track there are 7 railway crossings, 9 crossovers and 14 switches, but there has been no adjusting of the rails or switches on account of the rails creeping.

Further proof of the value of devices of this kind is afforded by another installation made by the railway mentioned above, on a piece of double track extending from the end of the Ohio River bridge to the 7th St. station. This track was laid with 75-lb. Am. Soc. C. E. rail, and had very heavy steam (and also electric passenger car) traffic over it, while there were many industrial switches leading from the two main lines, as well as crossovers, etc. The creeping of the rails being extremely heavy, fully 33% of the maintenance expense on this track was in respacing ties and driving back the rails at the frogs and switches. The track was equipped with oak ties, and about 6 in. of rock ballast. In 1908, the company applied four Positive anchors to each rail (8 to the panel), and since then there has been no expense in respacing ties or driving the rails back, as the creeping of the rails has been stopped completely.

The Effect of Cement Competition on the Stone Industry

By Edwin C. Eckel*

In a recent volume† on building stones and clays, the present writer devoted considerable space to consideration of the methods of valuing stone properties, and discussed most of the factors which bear upon that question. One important feature, however, was dismissed with far less attention than its importance seems to warrant, and as it bears directly upon the work of the engineer, this portion of the discussion has been put in shape for publication in this journal. In its original form the discussion covered all of the factors which might influence, in any way, the valuation to be placed upon either active quarries or undeveloped stone properties. As here presented, however, no consideration is given to the general principles of valuation, for these were discussed at sufficient length in the book, and the present discussion is restricted solely to the effects which the competition of portland cement and allied products will probably have on the future development of the stone industry. This is a matter which is of interest not only to the quarryman and cement manufacturer, but to the engineer engaged in general practice, and an attempt has been made to consider it in a broad way.

The Growth of the American Stone Industry

When considered by itself, from a purely statistical point of view, the growth of the stone industry in the United States during the past decade or so might seem to have been very satisfactory. If we merely say that in 1900 the total value of stone produced was a little over 41 million dollars, while in 1910 it was over 82 millions, the effect produced on the stone trade is certainly cheering, rather than otherwise. If we add casually that this total value is surpassed only by iron, gold and copper among the metallic products of the United States, and by coal, oil and clay products among the non-metals, the reader's conviction of both the present importance and the intrinsic soundness of the quarry industry is intensified. Stopping at this point, he might even find time to express a little surprise that the much advertised growth of the cement industry has had so little apparent effect upon the stone trade.

It may be of advantage to the quarryman, already involved in the business, to retain these optimistic views without further question, but the engineer who is charged with the examination or development of either an active quarry enterprise or an unopened stone property must examine the conditions and prospects of the industry in a more critical way. Such examination will show that the competition of portland cement and other manufactured structural materials *is* beginning to tell very heavily against certain branches of the stone industry; and it will suggest that this competition is likely to become more serious, rather than less so, in the future. On the other hand, it will also show that some types of stone have little competition from artificial products; and that certain stone products are likely to become more important in the future, regardless of the growth of the cement and clay-product industries.

Total Stone Output, 1900-1910—For the purposes of this study we have available a great mass of statistics, gathered with some care and published with proper deliberation by the U. S. Geological Survey. Like a few other publications of this efficient organization, the stone statistics are apt to prove difficult for use by the casual reader. It may be noted, for example, that the stone totals do not include slate; that furnace flux is included, but stone used in lime and cement manufacture is not; and that the "sandstone" totals are reported exclusive of "bluestone." For these reasons most of the figures have to be rearranged before being fit for general consumption. The reasons for these vagaries are interesting enough, but they do not require discussion here. It is possible that in re-arranging these data the present writer has introduced some errors of his own, but these will not be serious.

The accompanying little summary (Table I) contains data on the total stone production of the United States for the years 1900-1910, inclusive.

TABLE I. U. S. STONE PRODUCTION, 1900-1910

Year	Value	Year	Value
1900	$41,211,243	1906	$72,147,140
1901	52,071,708	1907	77,125,025
1902	60,494,733	1908	72,029,316
1903	63,690,026	1909	76,786,617
1904	64,382,910	1910	82,757,343
1905	69,294,955		

In the eleven years covered by this table, the total output of stone in the United States has almost exactly doubled. So far this result seems satisfactory enough, and it is only when we carry the comparison further that any effect of the competition of other products becomes noticeable.

Comparison of Stone, Clay and Cement Production—Of course, the comparison which would naturally be taken up first is one dealing with the total outputs of stone, cement and clay products over a period of years. This is made in Table II.

TABLE II. STONE, CEMENT AND CLAY PRODUCTION, 1900-1910

Year	Stone	Clay products	Portland cement
1900	$41,211,243	$96,212,345	$9,280,525
1901	52,071,708	110,211,587	12,532,360
1902	60,494,733	122,169,531	20,864,078
1903	63,690,026	131,062,421	27,713,319
1904	64,382,910	131,023,248	23,355,119
1905	69,294,955	149,697,188	33,245,867
1906	72,147,140	161,032,722	52,466,186
1907	77,125,025	158,942,369	53,992,551
1908	72,029,316	133,197,762	43,547,679
1909	76,786,617	166,321,213	52,858,354
1910	82,757,343	170,115,974	68,205,800

This table shows that while the total stone output has doubled in the period from 1900 to 1910, the clay-product output has increased 76%, but the portland-cement output has increased 635%. These results are brought out more clearly when put in diagrammatic form, and Fig. 1 has accordingly been prepared to illustrate them.

The writer recently made a long series of comparisons of the world's output of the principal metals during the same period—1900-1910—as is covered by the preceding table. This study seemed to show that the *average* industrial growth during that period amounted to a little under 60%. On that basis, all three of the products we are now concerned with increased at rates above the average. The rate of increase of stone and clay products was not far above the average, but the cement rate was phenomenally above it. It is only when we take up an

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†"Building Stones and Clays," by E. C. Eckel. Published by John Wiley & Sons, N. Y. Reviewed in Engineering News, July 18, 1912, p. 139.

examination of the stone output by kinds and uses that some idea is gained as to how this remarkable cement production has affected the stone industry, reducing the output of certain kinds of stone but actually tending to increase the output of other kinds.

Stone Output by Kinds

In Table II the total American stone output, during the years 1900-1910, inclusive, is grouped according to kinds of stone produced. This table differs from official presentations of the matter, because slate has been added, and the distinction between bluestone and sandstone has been dropped.

On looking over this table, it will be seen at once that the different kinds of stone have increased in output at very

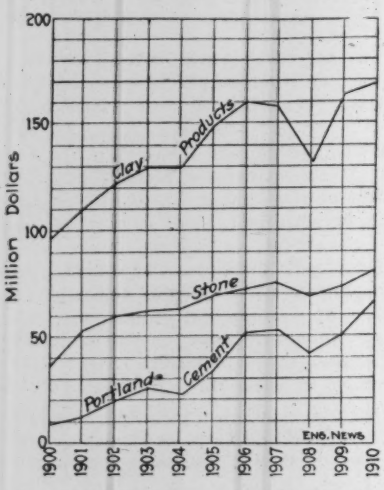


Fig. 1. Comparison of the Value of Stone, Cement and Clay Products in the United States, 1900-1910

different rates. Granite, for example, has practically doubled in output during the period under consideration, trap has shown a still greater rate of increase, while sandstone has barely held its own. Indeed, the sandstone production of the United States reached a maximum in 1903, and since then has actually shown a decrease in each year. Slate shows an increase of about 50% over the period, and marble about the same. But limestone shows an increase of remarkable amount. Fig. 2 places the matter in diagrammatic form.

Some of the reasons for the different rates of growth shown by the output of different types of stone appear when the question of use is considered.

The Utilization of Stone

It has already been noted that the limestone used in making lime and cement is not included in the stone statistics as published and as here presented. Sandstones used for abrasive purposes are also excluded; and a few minor uses for stone are doubtless omitted from the statistics. But even with these exclusions, the various utilizations of stone which are represented are more numerous than might casually be assumed. They include the use of stone for strictly building purposes, for rubble and riprap, for monuments, for flux, furnace lining, roofing, slabs and mill stock of various decorative and useful types, flagstones, curbing, paving blocks, and crushed stone for road metal, railway ballast and concrete.

Table IV gives data on the uses to which the various kinds of stone were applied during 1910, the figures for 1911 not being of as much importance because it happened to be a year of general business depression.

Growth of Various Utilizations

The data so far presented have thrown some light on the growth of the stone trade in general, and on the uses to which the various types of natural stone are now applied. It will be of interest to put the available statistics in such form as to bring out more clearly certain tendencies in this growth, and if possible to determine how the increasing supply of competitive materials has affected the various uses of stone.

The conditions in these regards are shown when the data are arranged, as in Table V, to show the growth of the various utilizations of stone during the past decade. It is not necessary to do this year by year, for the tendencies are unmistakable, and clearness suffers from overmuch detail. For this reason the conditions in the years 1901, 1904, 1907 and 1910, respectively, are shown.

In considering the facts brought out by Table V, it must be borne in mind that the industries of all the world are growing, that those of the United States are in general developing at a rate much higher than the world's average, and that we may fairly assume this world's aver-

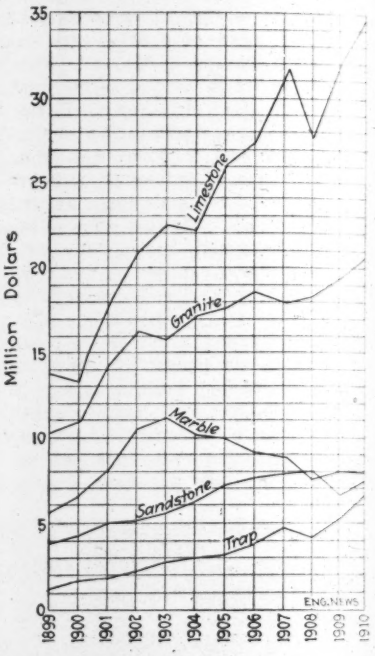


Fig. 2. Value of Different Kinds of Stone Products, United States, 1899-1910

age increase in industrial growth at 60% for the decade under consideration. Any industry which shows less than this rate of growth has, therefore, fallen back relatively to other industries.

The application of these general principles to the case in hand is obvious enough. On looking over Table V it will at once be seen that some of the various

TABLE III. VALUE OF AMERICAN STONE OUTPUT, 1900-1910

Year	Granite	Trap	Slate	Sandstone	Limestone	Marble	Total
1900	$10,969,417	$1,706,200	$4,240,466	$6,471,384	$13,556,523	$4,267,253	$41,211,243
1901	14,266,104	1,710,857	4,787,525	8,138,680	18,202,843	4,965,699	52,071,708
1902	16,083,475	2,181,157	5,696,051	10,594,483	20,895,385	5,044,182	60,494,733
1903	15,703,793	2,732,294	6,256,885	11,262,259	22,372,109	5,362,686	63,690,026
1904	17,191,479	2,823,546	5,617,195	10,273,891	22,178,964	6,297,835	64,382,910
1905	17,563,139	3,074,554	5,496,207	10,006,774	26,025,210	7,129,071	69,294,955
1906	18,562,806	3,736,571	5,668,346	9,169,337	27,327,142	7,582,938	72,147,140
1907	18,064,708	4,594,103	6,019,220	8,871,678	31,737,631	7,837,685	77,125,025
1908	18,420,080	4,282,406	6,316,817	7,594,091	27,682,002	7,733,920	72,029,316
1909	19,581,597	5,133,842	5,441,418	8,010,454	32,070,401	6,548,905	76,786,617
1910	20,541,967	6,452,141	6,236,759	7,930,019	34,603,678	6,992,779	82,757,343

TABLE IV. USES OF STONE OUTPUT, 1910

Use	Granite	Trap	Slate	Sandstone	Limestone	Marble	Total
Building stone	$5,609,313	87,832	.....	2,778,892	5,272,024	2,357,795	$16,105,856
Rubble and riprap	900,923	.....	.....	698,617	2,168,174	.....	3,767,614
Monuments	4,347,992	.....	.....	.....	.....	2,170,981	6,887,542
Flagstones	44,338	.....	.....	649,079	36,807	.....	730,224
Curbstones	1,019,529	.....	.....	881,902	165,781	.....	2,067,212
Paving blocks	2,823,772	225,645	.....	899,595	464,837	.....	4,413,849
Roofing	.....	.....	4,844,664	.....	.....	.....	4,844,664
Slabs, etc	.....	.....	1,392,095	.....	.....	2,039,596	3,431,691
Flux, etc	.....	.....	.....	.....	9,708,133	.....	9,708,133
Furnace lining	.....	.....	.....	404,197	.....	.....	404,197
Crushed stone							
Road metal	1,957,206	3,104,353	.....	253,970	6,595,717	.....	11,911,246
Railway ballast	818,142	983,370	.....	248,198	4,288,431	.....	6,396,191
Concrete	1,432,764	1,897,185	.....	903,985	4,781,214	.....	9,957,098
Unspecified uses	1,219,519	153,756	.....	211,584	1,122,560	424,407	3,131,826
Total output	$20,541,967	6,452,141	6,236,759	7,930,019	34,603,678	6,992,779	$82,757,343

utilizations of stone have shown little or no growth during the past decade, that others have grown at about the average rate, and that a few have shown rates of growth far above the average.

Nine utilizations of stone are separately named in the table. Of these, three—building stone, flagging and curbing, and roofing slate—have shown practically no increase during the decade. Monumental stone shows an increase of about 50%, which is about what we have assumed as the average or normal increase for any industry. Two utilizations—paving blocks and slabs—have doubled in output. Two—road metal and railway ballast—have practically tripled; and one—stone for concrete—has almost quadrupled in importance.

The Effects of Competition

With the principal facts regarding the growth of various parts of the quarry industry placed in definite form, it is now possible to determine quite closely what effect cement competition has had on the stone industry during the past decade, and to make some estimate of what further effects the future may hold. These effects are regulated primarily by the particular use to which the stone is to be put.

It is obvious that when a stone is used for a purpose for which its particular chemical composition is a requisite, no manufactured product is likely to displace it for this use, or even compete with it seriously. The amount of limestone used for furnace flux, or in the sugar industry, will increase with the general demands of those industries, and will not be affected either favorably or unfavorably by the growth of the cement or clay-product industries. Specific physical properties may also place a stone out of reach of competition for some particular use, though here there is more chance that a manufactured product will ultimately be made with the proper physical character. On the other hand, stone used for purely structural purposes is open to competition of a very serious kind; and the building-stone production may not increase much even though other lines of the quarry industry are prosperous. Finally, crushed stone is entirely free from cement competition; and the demand for crushed stone for concrete will actually increase with the growth of the cement industry.

As these considerations will affect the different kinds of stone unequally, owing to the different uses to which they are best adapted, the matter may well be taken up with reference to the various types of stone.

Granite—The output of granite has approximately doubled during the past ten years. At present about one-quarter of the total output is used for building; another quarter for monuments; another as crushed stone; and the remainder for miscellaneous uses, of which the most important is paving blocks. This division is by values; if we had any satisfactory data regarding quantities, it would be found that the crushed-stone industry takes up a much larger proportion of the total output.,

The monument trade cannot be seriously affected by artificial products, and is subject merely to the slow growth of taste and civilization. Granites make the best of our building stones, all things considered, and the structural-granite trade will be affected less by cement than other types of stone. It cannot, however, be expected to grow rapidly in future; but it will probably hold its own. As for the crushed-granite output, that has increased rapidly in the past, and the rate of growth is apt to be large for the future.

Trap—Having practically no use as building stone, the output of the trap quarries does not come into serious competition with manufactured products in any market. Most of its uses are likely to show large increases in future.

Slate—The slate output has increased about 50% in ten years; the growth being in milled slate rather than in roofing slate. Neither use comes in direct competition with portland cement used alone, but both uses now meet competition from manufactured and natural products. For roofing products, there are very satisfactory artificial slates made from magnesia cements, and from a mixture of asbestos and portland cement. For milled slabs, similar artificial combinations are available, and there is also heavy and increasing competition from soapstone. Under these circumstances the slate industry must be put on a modern footing, or else ordinary slates will fail to repay quarrying. Slates of special color and type are, of course, still practically free from competition.

Sandstone—As explained in the writer's book on building stones, the class of sandstones contains some of our very best structural materials, and some of our very worst. Sandstone is merely a fine-grained natural concrete; and unless it is very good there is no reason for preferring it to artificial concrete. Except with the very best of the sandstones, therefore, the prospects for profitable structural stone quarries do not seem very bright. The flagstone industry is also meeting severe and increasing competition from cement flagging. Most of our commercial sandstones do not make good crushed stone for road use, so that the waste stone of a flag- or building-stone quarry is not profitable. Taken as a whole, the sandstone industry has more to fear from competition than any other type of stone.

Limestone—With a few exceptions, the structural limestone industry will probably show little growth in future, but the waste stone is so generally serviceable that the effect will not be as serious as in the sandstone trade. Taken as a whole, the limestone trade will grow rapidly, but the growth will be along the lines of fluxing stone, and crushed stone for various purposes.

A limestone quarry whose product is high in lime carbonate is still a valuable asset, because the stone will find chemical uses as the structural-stone business dies down. An impure limestone, whose clay or silica is evenly distributed throughout the mass may make excellent crushed stone. But a cherty or other impure limestone, with irregularly distributed impurities, is apt to prove unserviceable even for such uses.

Marble—As structural stone for exteriors, the highly crystalline marbles are attractive but not serviceable in industrial towns. The semi-crystalline marbles are somewhat better in this regard Their competition, however, will not be against cement, but against more durable natural stones, such as the granites and better sandstones.

For interior decorative use, the marbles are both attractive and serviceable. Here such competition as they meet will not be from portland cement, but from various hard-finish plasters and other gypsum products.

TABLE V. GROWTH OF VARIOUS UTILIZATIONS, 1901-1910

Use	1901	1904	1907	1910
Building stone	$15,112,600	$18,883,455	$16,675,811	$16,105,856
Monumental stone	4,734,699	5,991,714	6,978,949	6,887,542
Flagging and curbing	2,797,849	3,577,070	3,918,799	2,797,436
Paving blocks	2,180,341	2,834,060	3,540,941	4,413,849
Roofing slate	4,114,410	4,669,289	4,817,769	4,844,664
Slabs and mill stock	1,681,579	2,227,423	3,127,453	3,431,691
Road metal	4,437,755	6,562,973	9,669,244	1,911,246
Railway ballast	2,306,196	4,508,056	5,721,289	6,396,191
Concrete stone	1,816,481	4,459,093	6,663,764	8,957,098

An Oscillating Railway Signal to be used as a warning to pedestrians or vehicle riders at highway crossings is in use by the Pacific Electric Ry., of Los Angeles, and is built in the company's shops. As described in the "Railway Age-Gazette," a hollow disk is attached to the stem of a forked rod, the arms of which are pivoted to a box mounted on top of a post and extend below the pivot to carry counterweights. The disk is lettered "Stop; Lookout," and has at the center a pair of 4-in. red glasses with an electric light between them, showing red in both directions. On the top of the machinery box is a 12-in. gong. As a car or train approaches, the gong is set ringing and the disk oscillates at the rate of 30 times per minute.

The signal is in use also on the Atchison, Topeka & Santa Fé Ry. The patents are owned by the Automatic Flagman Co., of Los Angeles, Calif.

Street Railway Track Work at Toledo

By A. Swartz*

Track reconstruction and repair on street railways presents many special conditions and difficulties, especially in keeping the lines open for traffic and in so arranging the plant and material as to minimize the interference with ordinary street traffic. Work of this kind is of an entirely different character from that of reconstruction and repair work on the open track of steam or electric railways on their own right-of-way. The article published herewith describes some double-tracking work on a busy street-car line, and gives particulars also of the repair and maintenance work and organization of an electric street-railway system.

*Engineer Maintenance of Way, Toledo Railways & Light Co., Toledo, Ohio.

The Toledo Railways & Light Co., operating the street-railway system in Toledo, Ohio, has this year relaid with double track that part of its Monroe St. line between 19th St. and a point west of Lawrence Ave. This stretch of 5340 ft. was single track, with three passing sidings. The track was in the center of the street, and spread to both sides of the center line at the sidings. On this street are operated two lines, the Long Belt and Short Belt. On the Long Belt there are various large industries so that the best transportation facilities are absolutely necessary. Between 6 a.m. and 8 a.m., cars are run on a 2½-min. schedule in both directions. From 8 a.m. to 4 p.m. the schedule is 5 min., while from 4 to 6 p.m. it is 3½ min. in each direction. It will be seen, therefore, that at any one given point on this stretch of track there are about 370 car movements between 6 a.m. and 6 p.m.

Double-tracking

This Monroe St. stretch of single track had 9-in. 90-lb. girder rails laid on 5x8-in. ties, 7 ft. long, on a 6-in. bed of concrete. The pavement was 4-in. creosoted wood block on a concrete foundation. This track was taken out in its entirety (except at the Collingwood switch, where the concrete foundation was left), and was replaced with 6-in. 100-lb. openhearth T-rail on sawed white-oak ties (untreated) 5x8 in., 7 ft. long. The ties are on a 3-in. bed of stone ballast (½ to 1¼ in.), under which is a 5-in. base of 1:4:6 concrete. The rail joints have four-hole Continuous angle bars with 1-in. bolts. The rails are 60 ft. long, laid with broken joints, and with 30 ties per rail. No expansion shims were used in tracklaying, the rails being laid with close joints. The construction of the new track is shown in Fig. 1.

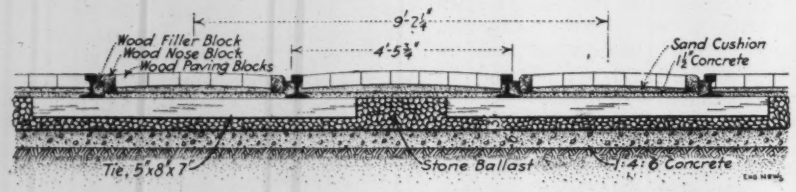


Fig. 1. Cross-Section of New Double-Track Line on Monroe St., Toledo, Ohio
(Toledo Railways & Light Co.)

The stone ballast was applied flush with the top of ties and rolled with a 10-ton steam roller. On top of this was placed a 1½-in. layer of concrete to keep the ballast and roadbed free from water from the street. Neither tie-plates, tie-rods nor rail braces were used. On the inside of the rails a wood filler block was placed next to the web of the rail. Next to this was placed a wood nose block, or one which has a corner beveled off so as to provide a flangeway for car and vehicle wheels. The paving blocks were laid on a ¾-in. cushion of sand, and the joints are filled with sand instead of the customary pitch or tar filler. Track drains were put in the center of both tracks at depression breaks in the grade of the street.

The web of the rail along the outside of the track was filled with rather dry mortar, against which the paving blocks were laid. The tracks were laid 9 ft. 2¼ in. centers, with the inside rails ½ in. higher than the outside rails to fit the contour of the street surface. The rails were bonded with 9-in. flat bonds, which were applied by a bonding car. Cross bonds were installed 200 ft. apart. This class of construction is considered about the best obtainable without excessive cost. The 3-in. ballast well tamped under the ties is enough to thoroughly surface the track and quite evenly distribute the weight to the concrete base. With more ballast as good and lasting a surface would not be obtained.

The old track was first torn up from 19th St. (the end of the older double-track) west to the first passing siding (at Collingwood Ave.), and a temporary track of new rail with opposite joints was laid on the north side of the street. When this strip was excavated and the concrete foundation laid, the temporary track was extended west to the third passing siding (at Maplewood Ave.), and the new tracks were laid west to Collingwood Ave. The second strip was then excavated and concreted, after which the temporary track was extended to the existing double-track west of Lawrence Ave. At Lawrence Ave. the Bancroft Belt double-track line was crossed temporarily by means of run-off switch points. These are merely straps of steel placed on wedge-shaped blocks of wood 6 in. high at the heel; they are 6 ft. long and held together by tie-rods. A pair was placed far enough on either side of the Bancroft line to allow all wheels of a car on the Monroe St. line to be on the level before mounting the following run-off. Flangeway grooves were cut in the rails of the Bancroft line. Fig. 2 shows the temporary running track at the left and the new permanent double-track line in position on the ballast.

Construction Methods on Double-tracking

Ties and rails for the south new track were unloaded from the temporary track on the north side of the street, the rails being placed by a derrick car which made a very quick job of it. The north track was laid afterward, with the derrick car located on the south track, as the distance between the north and temporary tracks was insufficient to permit of laying the north track first and using it to lay the south track without fouling operation on the temporary track. Whenever a stretch of about 600 ft. of new double-track was laid and the ballast deposited, the traffic was diverted to the new work. Ballasting was done under traffic, which helped to tamp it solidly. It was followed up at once by the concrete top and block paving. Ballast was deposited from 8-yd. dump cars.

On account of certain conditions, the tracks west of Lawrence Ave. were finished before that portion east of the avenue. The old track crossings here naturally had to be shifted and two additional crossings installed, which work was done by the derrick car standing on the new double track. It took an average of 10 min. per crossing, and as cars on Lawrence Ave. met at about this point, on a 10-min. schedule, practically no delay was encountered on that line.

The old concrete foundation was so well made as to require a traction steam shovel to excavate it as shown in

Fig. 3. However, one block of it was torn up with the rail derrick; taking out the rails first and then the concrete, which came out in large slabs, Fig. 4 shows the derrick car loading these slabs. For this work the derrick worked

FIG. 2. DOUBLE-TRACKING A STREET RAILWAY AT TOLEDO, O

(The two new tracks are shown in place. At the left is the temporary single track on ties laid upon the undisturbed part of the pavement.)

backward. At the Collingwood switch the ties were imbedded so thoroughly in the concrete that they were left in after adzing off 2 in. and creosoting the adzed face, on top of which the new ties were placed. At the Maplewood Ave. siding, however, the old ties (untreated) were quite easily taken out and found to be in first-class condition. They had been in place 17 years.

After the old concrete had been taken out and the subgrade prepared, the sand for concrete was dropped from dump wagons at the north side of the double-track trench, in the trench. The concrete mixer was placed in the south side of the trench. The crushed stone was dropped from dump wagons on the pavement south of the trench. The mixer averaged about 80 cu.yd. or about 225 lin.ft. of trench per working day. The concrete was allowed to set at least seven days before allowing traffic on it. For the concrete above the ballast, the mixer and crushed stone were located on the pavement on the south side of the street, and the sand and cement on the north side. Fig. 5 shows the mixer in position for this work. In the foreground is the stone ballast, while the white strip beyond indicates the top layer of concrete to prevent water from getting access to the ballast.

PAYMENT AND PROGRESS

The work of excavating, concreting and paving was performed on a force-account basis. That is, the work was let by contract and the contractor furnished all tools, machinery and supervision, while the railway company vouchered the contractors' pay-roll and allowed them a lump sum besides. The track work was done by the railway forces. The work was commenced July 8, 1912, and entirely completed Sept. 28, 1912. On account of a great deal of rain, there were only 64 working days, thus giving an average of 83 ft. per day.

FIG. 3. TEARING UP THE CONCRETE FOUNDATION OF A STREET RAILWAY TRACK WITH A STEAM SHOVEL

The above described construction is intended for standard as far as the style of paving will permit. The tendency in Toledo (and it is believed in many other large cities) is to pave with brick, creosoted block or sheet asphalt, so that this height of rail will fit any paving except Medina blocks, which are not much used now. Where sheet asphalt is used, this company paves from out to out of tie with brick or creosoted wood block.

GENERAL TRACK CONSTRUCTION

The great majority of rail now in use on this company's tracks is 9-in. T-girder rail. There is very little guard or groove-rail type in use, except on curves and special work. As a rule, the ties are of oak 5x8 in., 7 ft. long, spaced 2 ft. apart. The joints have 12-hole angle-bars with 1-in. bolts, and the spikes are ½x4½ in. A great deal of the track is laid directly on concrete, which is hard on rail ends and angle-bars; on other parts of the lines the track structure is laid on sand or gravel.

There are a number of different types of crossings, tongues, mates and frogs in use. The great majority of special pieces, however, are of the hard-center type and are 9 in. high. Nearly all regular crossings are of 9-in. 117-lb. or 125-lb. guard or groove rail, with hard-center construction, and are very substantial. Where steam roads are crossed, their tracks are carried on manganese work, while this company's rails are of open-hearth steel. The great majority of such crossings are of 100-lb. T-rail pattern. On non-paved streets or what may be termed open track, the track is laid generally with 60-lb. T-rail on cedar ties, ballasted with cinders or gravel.

The switches on open single track are usually of the street-railway type, composed of a tongue and mate, while the frogs are of the rigid steam-railway type. A number of electrically operated switches (operated by current from the

trolley wire) are used in the business district, where traffic diverts in one direction. Where more than one diversion occurs a switch tender is stationed.

Maintenance and Repair Work

There is one general store yard at which are kept all materials for reconstruction and ordinary maintenance; this is in charge of a foreman with a gang of men to load and unload. In this yard there are two large stiff-leg derricks for handling heavy materials, and there is a siding served by the L., S. & M. S. Ry. In the business district, at a trouble station or barn, is kept a small supply of materials for use of the track-trouble gang. Generally in the winter all work slated for renewal is measured up and estimates are invited from switch and frog manufacturers. Then, when necessary to make the renewal, the piece is ordered according to the estimate.

Fig. 4. Electric Derrick-Car Tearing up the Track and Concrete Foundation of a Street Railway Line at Toledo, O.

The track forces are generally in gangs of six or seven men under a foreman. When there is any work of consequence, two or more gangs are consolidated. A great deal of the repair work must necessarily be done at night, as day traffic is too great. After midnight, the owl-car service is on an hourly schedule, therefore more work can be accomplished at minimum cost. However, at times the paving is torn up and replaced during the day. A great saving on special work and relaying rail is made by the use of the rail derrick, as was plainly shown when the derrick was out of commission for a week. Certain gangs are kept busy making pavement repairs; others picking up low joints at special work or at rail ends; others renewing ties, surfacing and lining open track.

Fig. 5. Portable Concrete Mixer (on Pavement) Supplying Concrete for the Waterproof Covering of the Stone Ballast of a Street Railway Track

One gang, called the trouble gang, makes any class of small urgent repairs. These are reported at one trouble station, and each job is taken care of according to its importance. Each morning the roadmaster goes to the trouble station and looks over the reports, detailing the work to the trouble gang or other gang as he sees fit. A blacksmith is kept busy at the trouble station making repairs to the tools or any minor track-repair parts, the heavy work being repaired at the Central Ave. car shops. A time-keeper and material clerk visits each gang every day and checks the time as well as material used. Teams and work trains with flat cars are used to deliver repair materials.

A great deal of rail sawing is necessary by reason of applying "dutchman" where the rail ends are battered, but the balance of the rail is in good shape. This occurs mostly on track structure laid directly on concrete, but also quite frequently on other foundation. As a whole the girder type of rail lasts for 8 or 10 years and then is replaced mostly because of the tram becoming worn by reason of the wheel flanges riding on it. At present there are a great number of interurban roads using this company's rails, and the flanges on these car wheels are considerably deeper than the city cars. Generally speaking, hard-center work will last under present traffic 7 or 8 years in the business district, while in the residence district it naturally is of greater life.

Phenomena Beyond the Elastic Limit*

By Charles P. Steinmetz†

The first question which arises is: What is the elastic limit, and does such limit actually exist?

If a mechanical force of moderate value is applied to a structure it produces a deformation which is proportional to the applied force (or at least depends on it by a definite law), and which therefore disappears again when the mechanical force is withdrawn. Thus, a weight suspended from a steel wire or iron rod produces an elongation which is proportional to it (if the weight is not too large), and which, therefore, increases with increasing weight and decreases with decreasing weight, and finally disappears with a withdrawal of the weight. The relation between the applied weight or force F, and the elongation l produced by it, can thus be represented by the straight line OAO in Fig. 1, with the force F as abscissæ, and the elongation l as ordinates.

With forces of moderate value, this process of applying a force and withdrawing it again is *reversible*, and thus represents a reversible energy transfor-

*From a lecture at Stevens Institute of Technology, Hoboken, N. J. Reprinted from the "Stevens Indicator" and the "General Electric Review" of September, 1912.

†Chief Consulting Engineer, General Electirc Co., Schenectady, N. Y.

mation. In applying the force mechanical energy is impressed upon the steel wire or iron rod, and at any moment is equal to the applied force F times the elongation produced by it, and thus is represented by the shaded area OAB in Fig. 2. This mechanical energy is stored in the structure as the potential energy of the elastic forces produced by the elongation, and is reconverted into mechanical energy at the withdrawal of the force.

This phenomenon of a cyclic energy transformation at the application or withdrawal of a force is experienced not only with mechanical forces, but occurs with all forms of energy: magnetic, electrical, thermal, etc. Thus if we have a magnetic system, as a wire coil C in Fig. 3, and apply a magnetic force F (or, as usually called, a "magnetomotive force") to it, i.e., pass an electric current i through the wire coil, then we produce a magnetic deformation in the space inside of the wire coil, called a magnetic field ϕ, which is proportional to the magnetomotive force F, and thus appears and disappears with it, and can be represented in Fig. 4 by the same kind of diagram as the mechanical system in Fig. 1. This magnetic field ϕ is a condition of stress in space, which represents stored magnetic energy, shown by the area OAB in Fig. 4, and equal to $W = F\phi/2$ just as the stored mechanical energy in Fig. 2 equalled $W = Fl/2$.

If we have an electric system, such as two parallel cylindrical conductors, a and b, Fig. 5, like the wires of an electric transmission line, and apply an electric force (usually called an "electromotive force") E between the conductors, i.e., connect them to a source of voltage, then we produce an electric deformation, i.e., an electrostatic or dielectric field ψ between the conductors a and b. This field is again proportional to the applied force, and represents the stored energy $E\psi/2$, shown by the area OAB in Fig. 6.

Thus the phenomena are entirely analogous in the mechanical and the magnetic and the electrical systems in air: a deformation proportional to the deforming force, representing a cyclic energy transformation from applied energy to the stored or potential energy of elasticity, magnetic or electric field, and back.

If now, in the mechanical system, we still further increase the deforming force, and load the steel wire or iron rod for instance with greater and greater weights, finally a point is reached where, after withdrawing the force, the deformation produced by it does not completely disappear, but a permanent set remains. The steel wire, on taking off the weight, does not return to its original length, but a permanent or "remanent" elongation remains, and the relation between the applied force and the elongation then is represented by a diagram like OAR in Fig. 7. OA is the elongation during the increase of applied force from O to F_0, and AR the curve of elongation during the decrease of applied force, leaving OR as *remanent elongation.*

In this case, not all the energy impressed upon the steel wire by the applied mechanical force is returned. The applied energy is represented by the area OAB, and of this energy only the part represented by the area ABR is returned at the withdrawal of the force; while the difference, or the energy represented by the area of the loop $OARO$ is lost during the cyclic energy transformation, i.e., is converted into heat by *molecular mechanical friction.*

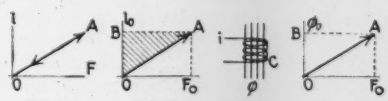


FIG. 1 ENG. NEWS FIG. 2 FIG. 3 FIG. 4

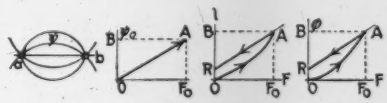


FIG. 5 ENG. NEWS FIG. 6 FIG. 7 FIG. 8

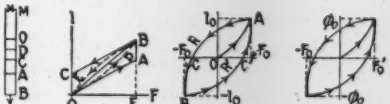


FIG. 9 FIG. 10 FIG. 11 FIG. 12 ENG. NEWS

FIG. 13 FIG. 14 FIG. 15 FIG. 16 FIG. 17 FIG. 18 ENG. NEWS

In such an irreversible cycle, as shown by Fig. 7, with the same applied force, the elongation is less with increasing force than with decreasing force; that is, with a cyclic change of force the elongation lags behind the force which produces it, and this phenomenon is therefore called *hysteresis,* that is, lag, and in the present case, *mechanical hysteresis.* Mechanical hysteresis thus represents the energy loss by molecular mechanical friction during a cyclic application of mechanical force beyond the elastic limit, and the *elastic limit* is that point where the cyclic process ceases to be reversible, i.e., an energy loss appears, and with it a lag or hysteresis, and a permanent deformation.

In the magnetic system in air no elastic limit exists, but the cyclic process remains reversible up to the highest magnetomotive forces. Irreversible cycles, however, appear in magnetic fields containing iron or other so called "magnetic materials," and in these the curve of rising magnetization, OA in Fig. 8, is different from and lower than that of decreasing magnetization, AR. These curves represent, respectively, the rising and the decreasing magnetic characteristic. Thus a loop is formed, OAR, the *hysteresis loop,* which by its area represents the energy consumed by *molecular magnetic friction,* and at the withdrawal of the magnetomotive force a *"remanent magnetism" OR* remains.

In the magnetic system containing iron or other magnetic materials the elastic limit is at zero; that is, even at the lowest magnetomotive forces the process is irreversible and hysteresis exists. It is thus interesting to note that the magnetic system represents separately and in different materials—air or unmagnetic materials on the one hand, magnetic materials on the other—the two types of the phenomenon, which in the mechanical system occur successively; the reversible process below, and the irreversible process above the elastic limit.

In the electric system air has no hysteresis, and the cyclic process is reversible. If, however, the two conductors, in Fig. 5, between which the electric field is produced, are inclosed by a solid insulating material, the cycle of application and withdrawal of electromotive force also becomes irreversible, at least at higher values of the force, and energy loss by *molecular dielectric friction* occurs and is measured by the *dielectric hysteresis loop.*

Below the elastic limit, in the mechanical system the energy transformation is reversible, i.e., perfect; or in other words, the efficiency of energy transformation from mechanical to elastic energy, and back, is 100%. An energy transformation without any loss is, however, against all experience, and the question thus arises whether below the elastic limit the process is really perfectly reversible, and whether the structure, as the steel wire, returns exactly to its original state at the withdrawal of the applied force. It is more probable that the elastic limit is that point above which the permanent deformation becomes appreciable, that is, above which an appreciable energy loss by mechanical hysteresis exists; while below the elastic limit the cyclic process may for all practical purposes be considered as reversible, that is, the permanent deformation and the energy loss during the mechanical cycle may be neglected under the condition of practical application. This makes the elastic limit a relative and not an absolute point, and with sufficiently accurate methods of measurement, permanent deformation may be observed below the elastic limit. This is in agreement with experience. While under average conditions of investigation, the elastic limit is fairly

definite, we know that even far below the elastic limit a permanent deformation occurs if the force is applied for a long time, perhaps centuries, as in supporting structures. Furthermore, where the material is exposed to very many mechanical cycles below the elastic limit, as under oscillating or vibratory stress, a structural change of the material finally occurs, which represents energy effects, and thereby shows that the cycle cannot be perfectly reversible, i.e., the energy cannot be completely returned.

There also is a time effect, a *viscous hysteresis,* which consumes appreciable energy even below the elastic limit, if the mechanical cycle is performed with sufficient rapidity. It is best demonstrated on materials such as rubber, which give a large elongation below the elastic limit.

Assume that a rubber band, Fig. 9, supported at M, is loaded by a weight or force F_0 at O. When suddenly applying the force F_0, an elongation of the rubber band MO takes place, to MA, and the elongation as function of the rapidly applied force is given by OA in Fig. 10. Leaving the force F_0 constant, the rubber band continues to stretch, first rapidly, and then more slowly, and reaches final elongation MB, as in Fig. 9. Suddenly withdrawing the force F_0 now causes the rubber band to contract again, but not to its original length, but to a greater length MC, leaving an elongation OC after the withdrawal of the force F_0. However, this elongation is not permanent, but gradually decreases, until finally the rubber band has returned to its original length MO. The elongation, as a function of the applied force, thus traverses the cycle $OABCO$ in Fig. 10, where OA and BC represent, respectively, the elongation and the contraction at the sudden application and the withdrawal, respectively, of the force F_0, and AB and CO represent, respectively, the gradual creepage succeeding the application and the withdrawal of the force F_0. The area $OABCO$ then represents the energy consumed in the rubber band by conversion into heat, during the rapid change of force, by *"time hysteresis"* or "viscous hysteresis."

If, however, the force F_0 is gradually applied and withdrawn, with extreme slowness, the elongation and the contraction follow the reversible cycle OBO in Fig. 10, and no energy loss occurs. Depending then upon the rapidity of application and withdrawal of the force, any curve within the area $OABCO$ may be traversed by the rubber band, and thereby any hysteresis loss experienced, varying between zero for infinitely slow application and withdrawal of the force, and a maximum $OABCO$, for instantaneous application and withdrawal of the force. Thus $OBCO$ would correspond to slow application, but instantaneous withdrawal of the force, $OABO$ to instantaneous application and slow withdrawal. Other curves are indicated by $ODBEO$, etc. This time hysteresis apparently exists, more or less markedly, in all materials exposed to mechanical forces, and is variously referred to as "after effect," "temporary set," "transient deformation," etc. Possibly it supplies the energy, which in the continued application of vibratory stresses causes the structural changes spoken of as crystallization, etc.

In the magnetic system an analogous energy loss, depending on the rapidity of the cycle, is caused by the *"eddy currents,"* even in unmagnetic materials, in which the elastic limit is at infinity; that is, the magnetic cycle is perfectly reversible, if performed with sufficient slowness. In magnetic materials, as iron, at very low densities even a true viscous hysteresis occurs.

In the electric system in solid dielectrics the time effect is very pronounced, and is spoken of as "soaking in of charges," "residual discharges," etc. Thus, if a charged condenser, as a Leyden jar, is discharged by short-circuiting it, after taking off the short-circuit gradually a charge appears again, and the condenser can once more be discharged; a third charge appears, and so on, giving a number of successive residual discharges of rapidly decreasing intensity, just as the rubber band in Fig. 9, when stretched to B for some time and then released, would contract to C. If locked at C, internal stresses would gradually build up, and when released the band would again contract to D; if locked at D, stresses would again appear, giving another contraction at release, etc.

In a mechanical system if we apply a force beyond the elastic limit, as for instance a tensile force F_0 to an iron rod, the elongation l_0 produced by it, OA in Figs. 7 and 11, does not disappear at the withdrawal of the force, but the iron rod contracts on the curve AR, leaving a permanent set, or a remanent elongation OR. A reverse force OC, Fig. 11, is thus required to bring the iron rod back to its original length; that is, reduce the elongation to zero. This reverse (in the present case compressive) force may be called the *"coercitive force."* Still further increasing the reverse force to the value $-F_0$, we now get a deformation (compression in the present case) equal to the elongation l_0 resulting from the same tensile force (provided that the deformation is not so large as to change the shape of the body). Withdrawing the compressive force $-Fo$, the compression decreases, on the curve BR' of Fig. 11, leaving a residual or remanent compression OR', which requires the application of a reverse coercitive force OC', to be reduced to zero. Thus by cyclically varying the applied force between equal and opposite limits F_0 and $-F_0$, that is, between tension and compression, a cycle of deformation results, as shown in Fig. 11. Such a cycle $ARCBR'C'A$ is called a *"hysteresis cycle,"* or *"hysteresis loop."* Its area measures the energy consumed in the material during the cyclic change of force, as *molecular mechanical friction,* as has been shown before; OR and OR' are the residual or *remanent deformations, OC* and OC' the *coercitive forces required* to overcome these deformations.

This cycle of mechanical hysteresis is the exact analogue of the cycle of magnetic hysteresis, Fig. 12; but while the cycle of magnetic hysteresis has been extensively studied and its laws are fairly well known, practically nothing is known regarding the cycle of mechanical hysteresis. Very little also is known about the corresponding electric cycle, the dielectric hysteresis.

Obviously, instead of between equal and opposite values of force, the cycle could be performed between any two values, of the same or opposite sign, and in the magnetic system such unsymmetrical cycles have been studied to some extent.

By observing hysteresis cycles between different limits of force F_0 and measuring their area, that is, the energy loss during the cycle, we can determine and plot in curves the energy loss per cycle, as a function of the limits between which the cycle is traversed.

In the magnetic system such hysteresis curves have been determined and studied for many years, and empirical equations found for the same. Usually they are plotted with the magnetic field, i.e., the deformation produced by the force as abscissas and the energy loss as ordinates, as shown in Fig. 13.

Corresponding curves of mechanical hysteresis could be determined, and plotted with F_0 or l_0 as abscissas, and the energy consumption w as ordinates.

Since in the mechanical system the cyclic process is reversible, or practically so, up to the elastic limit, the hysteresis loop would collapse, that is, include practically no area up to the elastic limit, but begin to broaden out beyond the elastic limit, and the curve of mechanical hysteresis would thus have a shape somewhat like Fig. 14, being practically zero up to the elastic limit E, and then rapidly rising. It is, however, practically unknown, and the entire field of irreversible mechanical processes has been very little explored. For this reason the analogy with the magnetic and electric system is of importance, as the latter has been studied to a considerable extent, and thus valuable conclusions may be drawn from the well known magnetic phenomena regarding the practically unknown mechanical phenomena.

Up to the elastic limit E, the relation between the mechanical force F and the deformation l produced by it is usually a straight line, or nearly so, like OE in Fig. 15. Beyond the elastic limit, the de-

formation usually increases more than proportionally to the force, as shown in Fig. 15. Thus by increasing the force F still further, finally a value D of the force F is reached, at which the curve of elongation becomes vertical; that is, the elongation l becomes infinite, or the structure of the body is destroyed; the body is pulled apart with tensile, crushed with compressive, forces. This limiting force D at which destruction of the body occurs, is thus called the *disruptive limit*, or the *breaking strain* of the material.

When considering the relation between force and deformation up to high values of deformation, obviously not the total force and total deformation must be considered, but the force per unit section of the body, and the deformation per unit length of the body. Otherwise, for instance, with a compressive force, owing to the increase of section by compression, a force which is beyond the disruptive limit for the original section of the body might still be below the disruptive limit for the increased section, and a tensile force below the disruptive limit of the original structure may cause disruption of the lessened section of the body, resulting from its elongation. In the same manner, in the magnetic system the relations are always given between magnetic field, i.e., magnetic deformation per unit section, and magnetizing force or field intensity, i.e., magnetomotive force per unit length of the magnetic system. In the following, therefore, when considering the relation between mechanical force and deformation, the force per unit section, and the deformation per unit length will always be considered.

There exists, then, two characteristic points on the deformation curve of a mechanical structure: the elastic limit E, where the mechanical cycle ceases to be practically reversible and appreciable mechanical hysteresis loss begins, and the disruptive limit D, where the deformation curve becomes vertical and mechanical destruction occurs.

The mechanical utility of materials very largely depends on the relative position of these two points with regard to each other. A permanent deformation is produced, by forces between E and D, and thus the shape of the body changed. Materials in which the range between the elastic limit E and the disruptive limit D is wide, as shown in curves I and II of Fig. 16, are called ductile, such as lead or gold. Materials in which the range is very small, or D and E coincide or practically coincide as shown in curves III and IV of Fig. 16, are called brittle, such as glass, etc.

It is interesting to consider the analogous phenomena in the magnetic and the electric systems. Magnetic forces have no disruptive limit, that is, the disruptive limit is infinity. Since with magnetic materals, such as iron, the elastic limit is at zero, such material thus shows in the magnetic system the analogue to perfect ductility. In unmagnetic materials the elastic limit is at infinity, and such materials thus show the phenomena of the reversible process below the elastic limit, over the entire range of forces. Thus the characteristics, namely, reversibility and ductility, which in the mechanical system succeed each other in the same material with increasing applied force, and can thus be observed in their purity over a limited range of forces only, appear in the magnetic system separated in different materials, and in each extending over the entire range from zero to infinity, and so can be studied over a very wide range.

In the electric system, with air, the disruptive limit coincides with the elastic limit at 30 kv. per centimeter, and air is thus dielectrically perfectly brittle. Electrically ductile bodies also exist; in many solid insulating materials there apparently exists a range of voltage application below the disruptive voltage, in which a permanent electrical change of the material occurs; that is, insulating materials are permanently impaired electrically by a continued application of electric forces below the disruptive limit, but above a more or less indefinite elastic limit.

Owing to the existence of a definite disruptive limit, in the electrical system the same partial breakdown may occur as in the mechanical system. For instance, if a beam of the shape shown in section in Fig. 17, that is, with a narrow rib, is loaded, the disruptive limit may be exceeded in the rib long before the elastic limit is reached in the beam. If the material of the beam is ductile, a deformation of the rib occurs which brings the stresses in it down below the disruptive limit. If the material is brittle, the rib is crushed or broken down. Thus in the electric field between two parallel conductors, such as two transmission wires shown in Fig. 18, with increasing voltage or electromotive force between the conductors, the disruptive limit of the air is passed at and near the conductors and the air thus breaks down at the conductors, and luminosity and energy loss occur, the so called *"corona."*

The electrostatic corona thus is electrically the same kind of partial or local breakdown through exceeding the disruptive limit, as is common in mechanical systems where an element or part of an element of a structure may fail by overstrain without involving the rest of the structure, as illustrated in Fig. 17.

In general, the phenomena of the mechanical system, reversibility below the elastic limit, ductility between the elastic limit and the disruptive limit, and energy loss by molecular friction, represented by a hysteresis loop, appear more clearly defined and more sharply separated from each other in the magnetic system and the electric system; and thus have been much further studied and are far better known and understood in the latter systems, the more so as, in experimental investigations, the magnetic and the electric systems allow a more perfect control of all conditions of experiment, and afford simpler and more accurate methods of measurement than the mechanical system. For this reason, in the study of the phenomena of the mechanical system, especially those beyond the elastic limit, which are of the utmost industrial importance, a very material assistance should be afforded by the analogy with the corresponding, but far better known, phenomena of the magnetic and electric systems, and often of other systems, such as the thermal, the chemical, etc. Thus the phenomena of perfectly reversible processes are most clearly represented in the magnetic field in air and other magnetic materials, the phenomena of brittleness in the electric field in air, of ductility in the magnetic field in iron and other magnetic materials, etc. It must be realized that these relations are not accidental analogies, but their meaning is that the phenomena of reversibility and irreversibility, of hysteresis and molecular friction, etc., are not specific mechanical, or magnetic, or other phenomena, but are general phenomena of energy transformation, and thus occur in all energy transformations, modified only in accordance with the nature of the energy. Thus the hysteresis loop appears as magnetic and dielectric hysteresis as well as mechanical hysteresis, as chemical hysteresis, as thermal hysteresis, etc.

Most theoretical investigations of the mechanical system have been limited to the range below the elastic limit, that is, the range where the processes are reversible, as the simplest case. When we consider the complexity of many theoretical investigations dealing with the relation of mechanical and elastic forces within the range of reversibility, the difficulty is realized of extending the investigation into much more complex range of irreversible processes beyond the elastic limit. In practice, however, the range beyond the elastic limit is fully as important as, if not more important than, the reversible range below the elastic limit, because it is in the range beyond the elastic limit where all materials are formed and shaped for their industrial use. Above the disruptive limit are carried out the operations of cutting, sawing, filing, drilling, and lathe and planer working. Above the elastic limit, but below the disruptive limit, rolling, drawing, forging, molding, swedging, etc., are done. The processes beyond the disruptive limit are not difficult in the calculation of their industrial energy relations; the problem is to apply energy in such a manner and of such intensity that the force at the point of impact of the saw, drill, etc., exceeds the disruptive limit of

the material acted upon, and the disruptive limit is a fairly definite value.

Far more difficult is the problem of dealing with the industrial operations which are carried out between the elastic and the disruptive limit, in the range where the cycle of mechanical hysteresis represents the energy required in shaping the material. If the curve of mechanical hysteresis, as a function of temperature, etc., were known, the power required by a rolling mill under any condition of operation could be calculated with the same exactness as the power consumed in the alternating magnetization of a transformer is calculated from the magnetic hysteresis law of the iron.

The mechanical hysteresis essentially depends on temperature and on time; for instance, in carrying iron through a mechanical cycle a very high energy is required at ordinary atmospheric temperature. Much less energy is required at dull red heat, and at white heat the energy of the mechanical hysteresis cycle of iron becomes very small. The elastic and the disruptive limit also greatly depend on the temperature; bismuth, for instance, which is very brittle at atmospheric temperature, can be drawn into fine wire near its melting point. Cast zinc, which is brittle and crystalline, can be rolled into thin sheets within a certain temperature range. Time also exerts a material influence; asphaltum, for instance, which shatters under a sudden blow as a brittle material, spontaneously flows, that is, changes its shape, under the small, but continuous, force of gravity.

Here, then, in the range of mechanical forces beyond the elastic limit is a wide field for further investigation, in which relatively little is known beyond isolated and more or less disconnected facts, but for which no comprehensive laws have yet been derived, like those which have brought the corresponding phenomena in the magnetic and the electric system within the reach of exact calculation.

Rapid-Transit and Highway Tunnels for San Francisco

A project for a rapid-transit tunnel under the Twin Peaks in the city of San Francisco, was noted in our issue of June 20, 1912 (p. 1203). The project was presented by a local improvement association and referred to Bion J. Arnold, who has been retained by the Board of Supervisors to report on San Francisco transportation problems.

This tunnel is to connect the business district with 8000 acres of new residential territory to the southwest, which has heretofore been cut off by a range of high hills, that made rapid transportation impossible. The first report approved the project in a general way.

Mr. Arnold has recently made a second report on the project, in which he has presented for the first time general plans for the construction of the tunnel and its connections; we give herewith a short abstract.

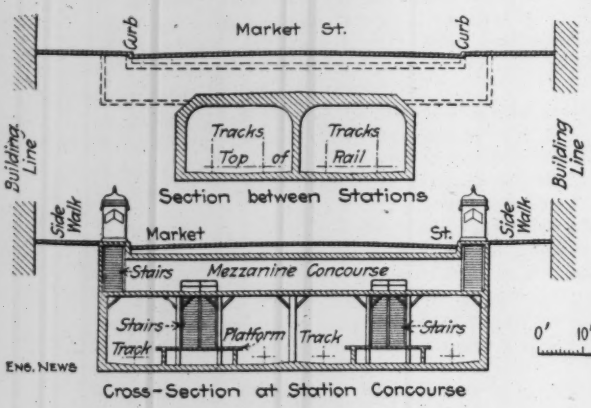


FIG. 1. STANDARD FOUR-TRACK SECTION WITH COMPLETE MEZZANINE CONCOURSE AND DOUBLE ISLAND PLATFORMS

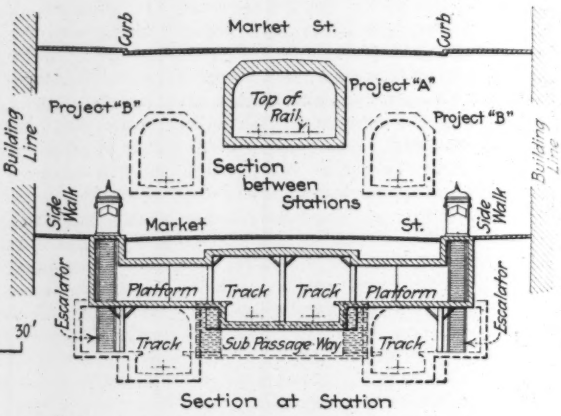


FIG. 2. THREE-BORE HIGH-AND-LOW LEVEL SUBWAY SECTION, WITH SUB-CONCOURSE AND MEZZANINE FLOORS FOR TRANSFER

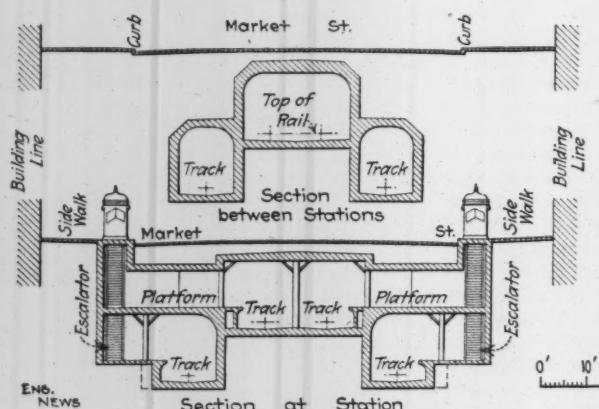


FIG. 3. THREE-BORE HIGH-AND-LOW LEVEL SUBWAY SECTION FOR UNIT CONSTRUCTION

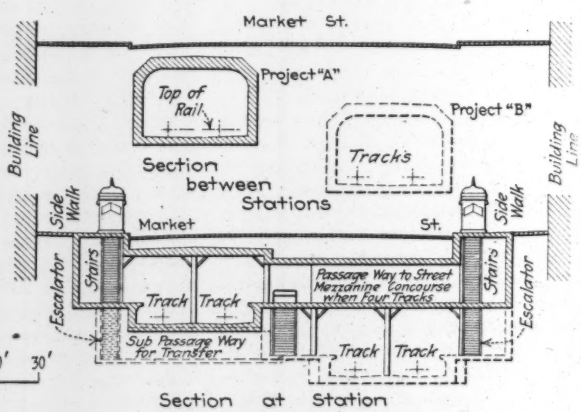


FIG. 4. TWO-BORE HIGH-AND-LOW LEVEL SUBWAY SECTION WITH TRANSFER FACILITIES

FIGS. 1 TO 4. PROPOSED SECTIONS OF PROJECTED MARKET ST. SUBWAY, SAN FRANCISCO, CAL.

RAPID-TRANSIT TUNNEL AND SUBWAYS—For the main tunnel, a single tube of a size sufficient for double-tracks is planned; but complications arose in studying the extension down Market St. Two different types of construction are held to be warranted for upper and lower Market St. and these, with modifications, give four types of sections now presented for consideration.

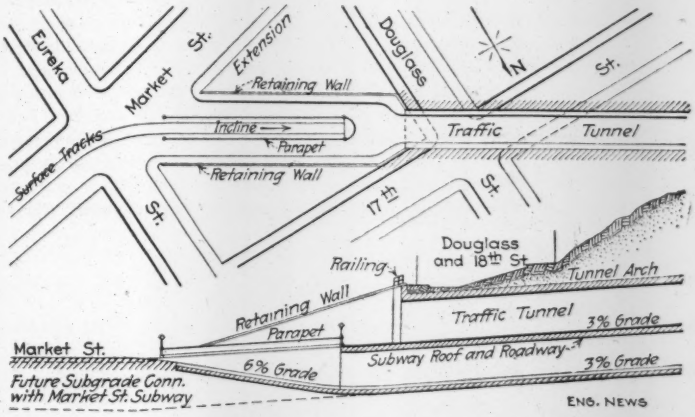


FIG. 5. PORTAL PLAN AND SECTION, MISSION-SUNSET TRANSIT-TRAFFIC TUNNEL; SAN FRANCISCO

The first is a flat-roof double-tunnel section at a depth permitting a mezzanine concourse between sidewalks and making the platform 23 ft. below surface level. This is the standard construction used in other cities and shows a minimum cost. The disadvantage of this design lies in having all platforms depressed 8 ft. extra to accommodate the mezzanine gallery.

The second section is shown in Fig. 2. The initial project ("A") covers the construction of a high-level, two-track tube. The second project ("B") would cover construction of two single track sub-level tunnels built later and having mezzanine concourses. By this section two platforms are brought 8 ft. nearer the surface at all stations. This is well suited to upper Market St., but is expensive because of the cost of driving independent tunnels and of the added walls.

The third section is similar to the second except that all three tunnels would be built as a single unit, saving in excavation.

The fourth section shows two two-track tunnels constructed at different times. The first one is at a high level, giving a mezzanine concourse later for the second tunnel when built. The intervening distance permits construction of the second project without disturbance to the first.

The first type was recommended by Mr. Arnold for lower Market St. and the fourth for the upper part of Market St.

In all these sections, a total depth of 4 to 5 ft. below the street surface, to the underside of the tunnel roof, is the minimum that was considered, including the surface tracks, 6- to 8-in. protecting cushions, a layer of waterproofing and the roof. The minimum inside height of the tunnel is taken to be not over 14½ to 15 ft. above rail head, bringing the station platforms to from 14½ to 15 ft. below the street's surface, as a minimum.

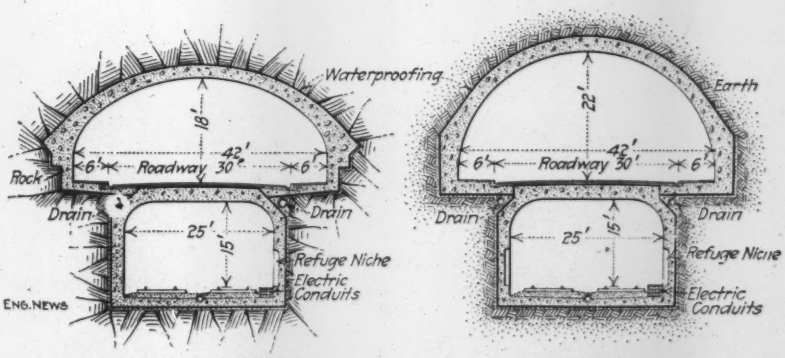


FIG. 6. CROSS-SECTIONS OF TRANSIT-TRAFFIC TUNNEL RECOMMENDED FOR MISSION-SUNSET PROJECT

TRANSIT-HIGHWAY TUNNEL—It is proposed that the projected Mission-Sunset tunnel (a crosstown tube from Market St. to Golden Gate Park, passing under the southern edge of Buena Vista Park, for vehicle and car traffic) might well be combined with a branch of the Market St.-Twin Peaks rapid-transit line. The design for such combination is shown by Mr. Arnold (Figs. 5 and 6). Instead of building the original Mission-Sunset highway tunnel of sufficient width for accommodating both traffic and car lines, the tunnel is now to accommodate only vehicle traffic and pedestrians from surface to surface. The car lines are to be run at a lower level beneath the roadway. Up to the time that subway cars are required for this branch district, the low-level tube may be reached by ramps at each portal. Ultimately this tunnel may be used by both subway and trolley cars, the subway tracks continuing to an intersection at subway grade with the Market St. line and the trolley cars coming out at the surface as before.

The section shown has the advantage of being suitable for construction in narrow streets. It removes danger arising from having the supporting struts of earth removed behind the abutment in the event of excavation by private parties along the street line. This, in the case of the wide-span arch with abutments close to the street line, would render the arch unstable. The reduced width of structure also obviates the necessity of requiring easement rights for protection of the structure.

Hydraulic Excavation in the Pacific Division of the Panama Canal will be completed about Dec. 1, 1912, when the plant will be shut down and dismantled. For some time past operations have been in the canal channel, south of Miraflores Locks, and have about reached the point where the cost of excavating by this method would probably exceed the cost by steamshovels. A good bottom has been obtained for shovel work on the east side of the channel below the dam, and from there the shovels will be in position to make favorable progress.

Excavation by the hydraulic method was begun in September, 1910, and the equipment was first used in filling the core of the west dam at Miraflores, the monitors at that time working in the lower lock site at Miraflores. The hydraulic fill of the dam was completed on Dec. 4, 1911, and amounted to 625,048 cu.yd. Prior to this time, the zone of operations had been moved further south into the channel section, and, when the fill of the dam was completed, the material disintegrated by the monitors and pumped out by the dredge pumps was carried to the nearby tidal swamps. A total of about 110 acres of swamp land had been reclaimed to Nov. 1, 1912. The total excavation accomplished by the hydraulic plant from the beginning of operations to Nov. 1, 1912, aggregates 1,723,800 cu.yd. During the fiscal year ending June 30, 1912, the total cost of handling the material, earth and rock, by the hydraulic method was $0.5564 a cu.yd.—[Canal "Record," Nov. 6, 1912.]

A Highway Bridge with Provision for a Future Draw Span; Trail, B.C.

By E. E. Howard*

For many years the only crossing afforded for highway traffic over the Columbia River, adjacent to Trail, B. C., in Ymir District, was by means of a ferry, of the well known cable type, operated by the current of the river. With the rapid development of the contiguous territory and the increase of population and travel it became necessary to provide a better crossing than that afforded by the ferry, and the government of British Columbia provided funds and arranged for the construction of a bridge.

The river at the site is of navigable depth, but at the present time there is no great amount of river traffic, so that it was considered unnecessary at the present time to provide a structure having a movable span. It is certain, however, that, with the increase of river traffic channel openings for boats at all stages of the river will be necessary. A construction fitted to the needs of the present, and yet so adaptable as to be modified with reasonable expense and without unreasonable waste to fit future conditions, capable of providing for trans-river travel, was the problem presented. This problem was solved by the use of a Waddell & Harrington vertical lift bridge, and the resulting structure is unique and worthy of notice, principally as illustrating an engineering solution of unusual conditions presented.

The present construction cost practically no more than an ordinary fixed bridge, and yet it can be converted to a movable bridge at comparatively small expense, and without the destruction or waste of any part now built. The final cost of the bridge, when made movable for river traffic, will be much less than the cost of a bridge including a rotating swing span.

The bridge as built (Figs. 1 and 2) consists of four duplicate through-truss-riveted spans, providing a planked roadway 18 ft. wide between guards, carried on timber joists. The spans rest on three cylindrical piers and on two abutments.

Each pier (Fig. 3) consists of two steel cylinders 6 ft. diameter at top and 9 ft. at bottom, filled with concrete. Each pair of cylinders forming a pier are joined together by a concrete web 2 ft. thick incased in steel and reaching from about low water to high water. The piers are thus very rigid. The south abutment rests on exposed bed rock and was built in the open. The southernmost pier was built in a coffer-dam, and the other piers by the pneumatic process. The variation of low to high water is great and the current swift, as may be noted in the view in Fig. 3, but construction was carried forward rapidly and without mishap. The abutments were of usual concrete construction, offering no extraordinary difficulties in construction.

The design and details of the steel work of the spans are such as to provide simple compact connections. The flanges of all truss members are turned in making simple arrangement of gusset plates, and presenting a neat compact finished appearance in the completed structure.

The specifications were somewhat more thorough than usually required for a highway span. The material is of medium steel and the shop work was of the best. Rivet holes were sub-punched and reamed with parts assembled. The trusses were assembled at shop and all field holes reamed. Rigid double plane portals are provided at each end. The steel work was painted with three coats of paint. The timber in joists, floor and hand rail was of best quality mountain fir, well bolted and fastened in place.

The structure, therefore, as it stands, commends itself as an excellent highway bridge, designed and built with all the care to detail customary on large structures, but so often lacking in smaller bridges. While built to carry only high-

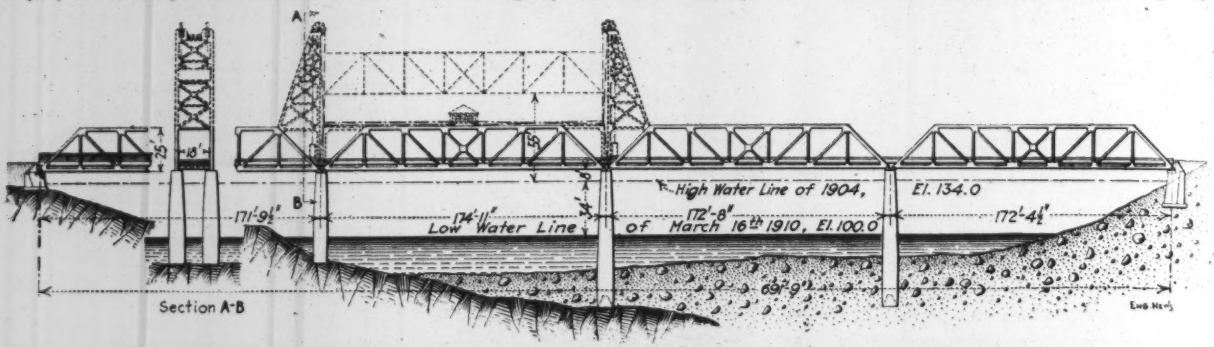


Fig. 1. Elevation of a Riveted Truss Highway Bridge across Columbia River, Near Trail, B. C.
(Dotted lines represent framework to be placed when river traffic requires the transformation of a fixed span to a draw span. Bracing between twin cylinders of pier not shown. See Fig. 3.)

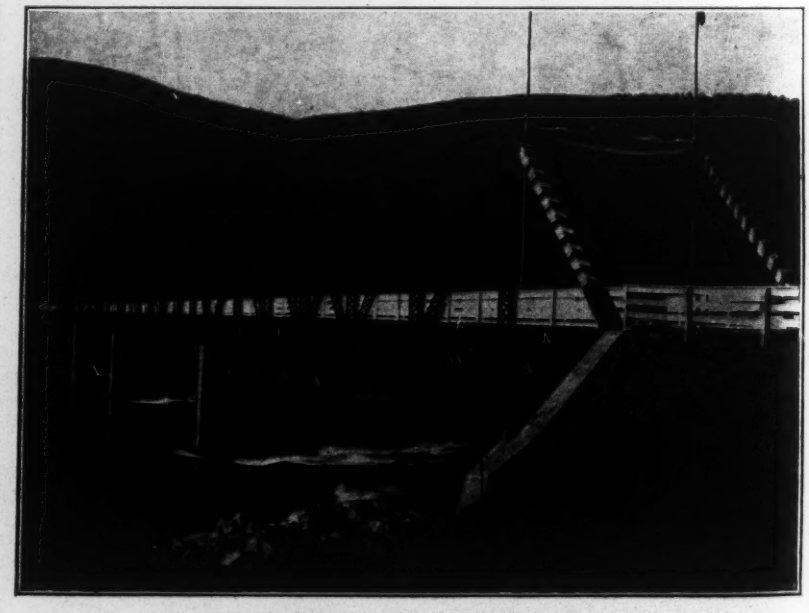


Fig. 2. Present View of Trail Bridge

*Associate Engineer, Waddell & Harrington, Kansas City, Mo.

way loading no detail of material or workmanship has been slighted, and in these respects it would be difficult to surpass the structure.

At any time this structure can be converted to a movable bridge by constructing towers at the ends of two spans, placing certain extra parts and machinery on the intermediate span, and arranging for it to be lifted and lowered at will, to a height sufficient for the passage of boats. Each tower consists of two columns braced together which will rest on the end shoe pins, and which are braced back to the fixed spans. The load of the lifting span thus comes only on the front columns, and practically no additional load is placed on the adjacent truss by the connection of the back leg. There will then be placed on the lifting span a cross-girder at each end connecting to hangers riveted between the gusset plates at the end floor beams. Steel cables for balancing the weight of the span are attached to these lifting girders, are led over sheaves at the tops of the towers and attached to counterweights of the concrete and steel. Machinery and a machinery house will be placed on the top of the movable span.

The counterweights will be built in elevated position, the machinery connected and the span be ready to operate. It is thus evident that the entire operation of making a span movable can be carried out without stopping traffic on the bridge.

The operating machinery, which will be carried on the top of the lifting span at the center, consists of four spirally grooved drums placed on center lines of chords, actuated through trains of gears by an electric motor. Each drum controls two operating ropes, one from the top of the drum leads over a sheave at the corner of the span, thence downward and is fastened near the bottom of the tower, and one from the bottom of the drum leads over the sheave at the corner of the span, thence upward and is fastened at the top of the tower. All four drums are similarly connected so that when they are revolved in one direction the ropes leading to the tops of the towers are wound on, and those connected to the bottom of the towers are paid off, thus raising the span by the lifting force exerted on the corner sheaves. Reversal of direction of revolution of the drums lowers the span. A solenoid brake with limit switch controls the movement of the span and a hand brake is also provided. The span may be operated by hand if desired. The machinery is thus very simple in character, is all in view in the operator's house, and consists principally of spur gears and the two shafts extending across the span connecting the operating drums. The four corners of the span are thus held definitely by the operating ropes at all times, holding the span perfectly level. The operating ropes are provided at their extreme ends with suitable turnbuckle adjustments so that they can be kept taut.

At one end the lifting span is held in position during motion by suitable roller guides engaging on tracks on the tower columns, maintaining a position both laterally and longitudinally, and at the opposite end of the span the guides maintain only a lateral position, so allowing for the expansion and contraction of the span.

As the spans are duplicates, the lifting machinery can be placed on any one of them, and either of the central spans made operative, or if desired, the end spans can be made operative by providing some small additional pedestals for the rear columns of the tower at the shore end.

This type of construction requires for the movable span piers of no greater size than are used for the simple spans. A single wide channel is provided, and as no draw protection or other construction in the river are required, boats can pass through at any angle. The span need be lifted only high enough to clear the vessel passing, and can, therefore, be operated with dispatch.

The complete plans for towers and machinery and all attachments necessary are prepared and are on file, including specifications for the construction of the new work. It will be, therefore, a very simple matter at any time desired to provide for the requirements of navigation.

The bridge is owned by the Province of British Columbia, and was designed under the direction of J. E. Griffith, Public Works Engineer, and the construction was under the supervision of Mr. Griffith's assistants, Messrs. Ford, Anderson and Broderick. The Cleveland Bridge Co., of Darlington, Eng., manufactured the superstructure, and Armstrong, Morrison & Co., of Vancouver, constructed the substructure and erected the superstructure. The design, plans and specifications were furnished by Waddell & Harrington, of Kansas City, and that firm controls patents on this type of movable bridge.

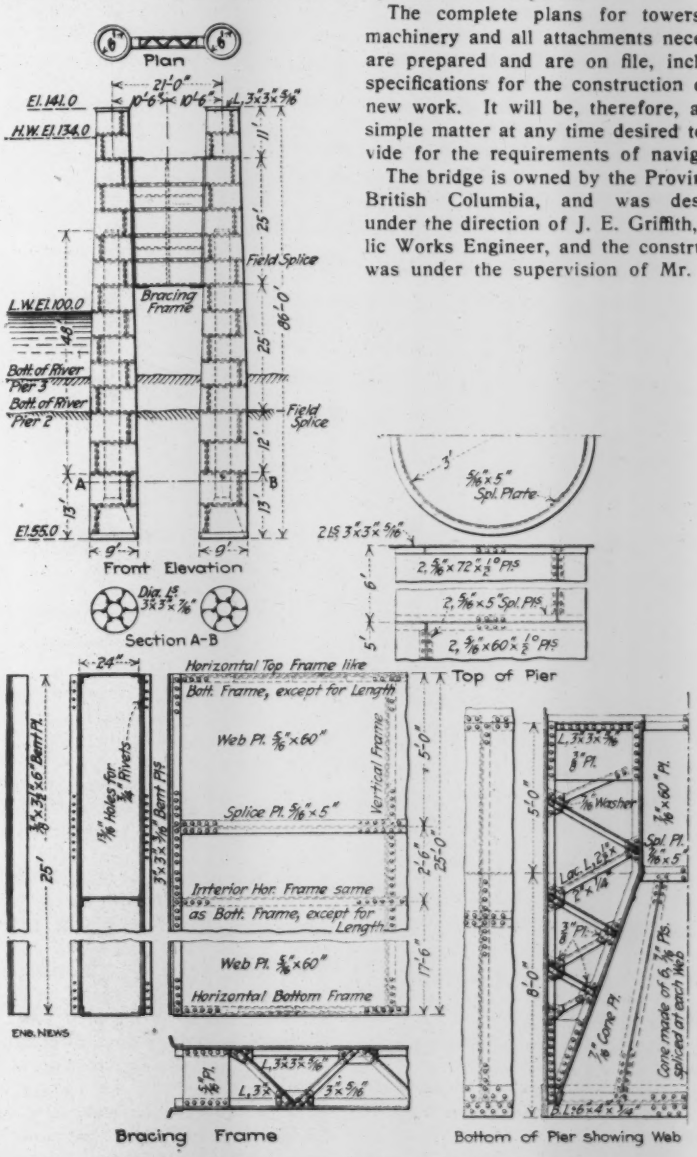


FIG. 3. DETAILS OF TYPICAL CYLINDER PIER

Turntable Design

A complete and authoritative review of locomotive turntable design and details was presented recently before the American Railway Bridge & Building Association by a committee headed by C. E. Smith (Bridge Engineer, Missouri Pacific Ry., St. Louis, Mo.). The review is authoritative because it represents the practice of all the principal railways of the country as determined by inquiry from their proper representatives, as well as the opinion of the committee based on a consideration of the diversified practice. It covers practically all matters connected with turntable design and construction in a way not found in print elsewhere, the subject being one that is greatly neglected in the current textbooks and periodical literature. In effect, this committee report is a treatise on the subject, of high-grade character, and we therefore reproduce its substance here as fully as the space at our command will permit.

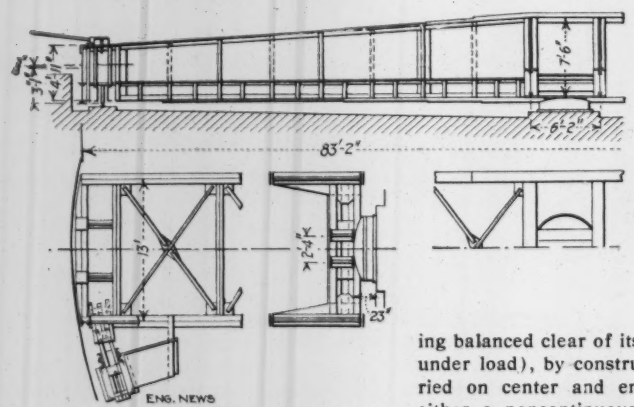


FIG. 1. STANDARD 85-FT. THROUGH PLATE-GIRDER TURNTABLE OF ATCHISON, TOPEKA & SANTA FÉ RY.

The committee's inquiries were answered by 57 railways operating 175,000 miles of line and including all the chief railways of the North American continent. The total number of turntables covered is not stated but is evidently very large; and it is also apparent that the practice of the present day does not represent all or even most of the turntables in service, since many of these structures are over a quarter century old.

CHANGES IN TYPE AND DESIGN

The factors which influenced change in turntable design during the last few decades is the weight and length of engine. Increasing length has required turntables to be built longer, and the combined effect of length and increasing total weight has brought about a very great increase in strength and stiffness of the table girders. Stiffness being an important element to limit the deflection (so that the required free play at the end of the turntable girders shall not be excessive), the design is much more dependent on stiffness when great lengths are reached than when the turntable is short. The deflection of a long table should not be greater than that of a short table, and therefore with long tables special means are required to secure stiffness.

Formerly all turntables were deck-girder structures, and relatively shallow girders sufficed for the duty. With greater length and load, much deeper deck girders were used, but with all practicable increase of depth, difficulty was experienced in securing the required stiffness. Through girders have, therefore, been used to a considerable extent, a few roads even making through girders their standard. One or two roads have used shallow girders trussed by a heavy, overhead suspension-tie trussing. An attempt in another direction was departure from the simple cantilever type (with center support only, the table being balanced clear of its end support even under load), by constructing a table carried on center and end supports, i.e., either a noncontinuous table or a table continuous over three supports, all three supports taking load under all conditions. Tables of this form have not been successful, however. The chief trouble seems to be that the great power required for turning a table when any material part of the load rests on the end trucks is a bar to their successful use. The low friction realized in the pure center-bearing type of table seems to be essential from the operating standpoint.

Turntable centers have also been made larger and heavier as tables grew in size. Apparently there is no particular difficulty in this direction, especially as swing bridges have centers operating under very much higher loads. The difference of opinion as to roller-bearing or disk centers for turntables does not appear to be vital, as both types are reported to be used successfully, and good examples of satisfactory design exist for both.

LENGTH OF TABLE

The standard turntable lengths of various railroads range from 75 to 90 ft. (nearly always on the 5-ft. intervals), and are almost equally divided over this range. Two railways (C. & O., N. & W.) report 100 ft. as their standard length, but five roads have one or more 100-ft. tables for large engines or to accommodate the required number of tracks without frogs in the approaches to the table (B. & O., G. T., O. S. L., Penn., U. P.). One railroad (C. M. & P. S.) has a few tables 105 ft. long to turn its long Mallet engines.

Mallet engines are the chief source of trouble in the matter of turntable length. While only one locomotive in the country has a wheelbase longer than 90 ft., the required length of turntable is under usual practice determined by the necessity of placing the center of gravity of the engine over the center of the table when turning; it should be possible to balance with tender either light or loaded. Thus, while 70 to 74 ft. is the maximum wheelbase length of engine and tender for all but Mallet engines, and Mallet engines of heavy type range from 72 ft. to 88 ft. (except the 24-wheel Mallet of the A. T. & S. F., whose total wheelbase is 108 ft. 1⅝ in.) yet the required balancing lengths range up to 90 ft. (94 ft. for Baldwin Locomotive Works' Decapod) and up to 105 ft. for Mallet engines (135 ft. for A. T. & S. F. 24-wheel Mallet).

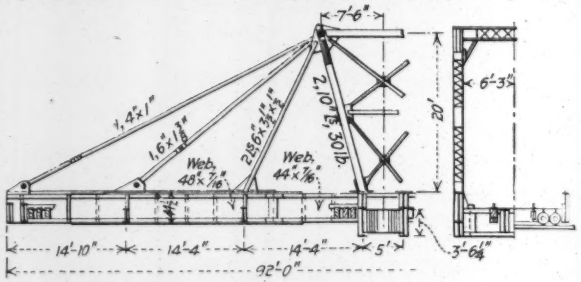


FIG. 2. GREAT NORTHERN RY. 92-FT. TRUSSED THROUGH TURNTABLE

On account of the great excess of balancing length over length of wheelbase, many roads now resort to the practice of placing end trucks under turntables to carry a certain amount of the locomotive load and thus make it unnecessary to place the engine so as to balance on the table. This practice is becoming quite common, particularly for Mallet engines. On the Pennsylvania Lines West these end carriages are cushioned by steel springs; others are rigid trucks.

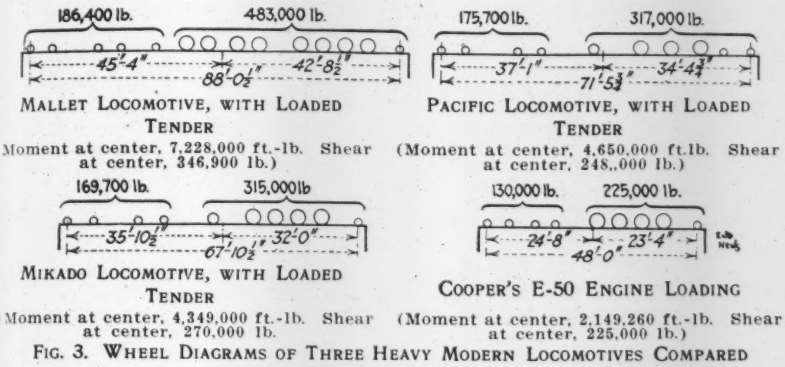
For turning engines of abnormal length it is considered that turntables need not be provided, as such engines are few in number and are in every way exceptional and should not complicate the design and use of turntables. Turning such engines on wyes is recommended as the proper expedient.

The committee recommends that standard turntable lengths should lie between 75 and 90 ft., the latter being recommended for roads using very heavy engines. Wye tracks should be provided

for engines having wheelbase over 90 ft. This, of course, implies that for engines approaching 90 ft. in wheelbase the tables should be provided with end trucks.*

Type of Table

The deck plate-girder type has at all times been the most popular and continues to be regarded as the most desirable where possible. However, the long



Mallet Locomotive, with Loaded Tender
(Moment at center, 7,228,000 ft.-lb. Shear at center, 346,900 lb.)

Pacific Locomotive, with Loaded Tender
(Moment at center, 4,650,000 ft.lb. Shear at center, 248,.000 lb.)

Mikado Locomotive, with Loaded Tender
(Moment at center, 4,349,000 ft.-lb. Shear at center, 270,000 lb.

Cooper's E-50 Engine Loading
(Moment at center, 2,149,260 ft.-lb. Shear at center, 225,000 lb.)

Fig. 3. Wheel Diagrams of Three Heavy Modern Locomotives Compared with Cooper's E-50 Loading

tables now required call for deep girders, and this means deep pits, which are likely to introduce drainage difficulties. On this account through plate-girders, and in some instances trussed girders, are employed. Figs. 1 and 2 herewith show a plate-girder through table and a trussed plate-girder table.

The spacing of girders of through tables should be at least 15 ft. c. to c., in the opinion of the committee. In some instances through girders have been found dangerous on account of insufficient clearance between engine and girder flange leading to injury to men.

Through plate-girders have been made the standard for turntable design on seven railroads (A. T. & S. F., G. T., Intercol., I. & G. N., N. & W., N. P., G. N.).

Nontipping Tables—A few tables of the so-called "nontipping" type have been used. These have the center and end supports in bearing at all times, the girders being continuous or noncontinuous, according to the designer's preference. The reports on their service are on the whole unfavorable (E. J. & E., Southern). There is excessive friction, great wear at bearings, damage to table from the great stresses set up in it while turning, etc.

Loading

The diagram Fig. 3 herewith illustrates the amount and distribution of load from three large locomotives, and in comparison therewith the Cooper E-50 loading. The figures for center moment given under the diagram make it evident that the Cooper loading is inadequate for turntable design. Nevertheless, some 15 railways use Cooper loadings, from E-50 to E-60. A number of others use the wheel-loads of the Cooper engines, but increase the axle spacing and wheelbase in order to approximate real conditions (e.g., S.A.L. uses E-50 with wheelbase increased 50%; B. and Alb. uses E-60 with wheelbase increased 10 ft.). Other railways use total engine weights in designing their tables, while about 25 roads use special engines representing the maximum in service on their system.

The committee recommends that turntables should be designed for the heaviest actual engine in service anywhere that could use the table.

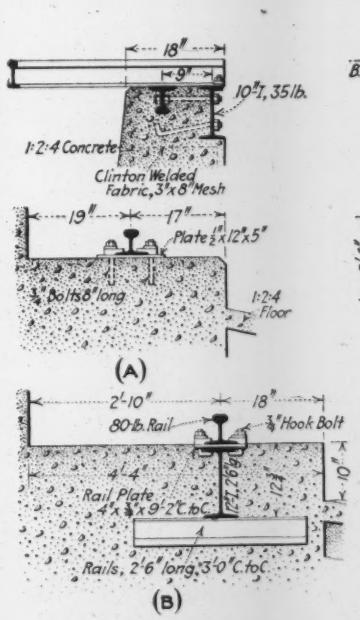


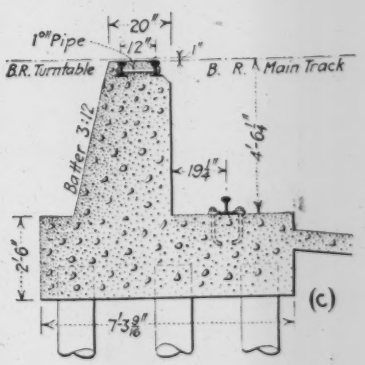
Fig. 4. Connection of Track Rails and Circle Rail to Circle Wall
A. Boston & Albany R.R.
B. Cleveland, Cincinnati, Chicago & St. Louis Ry.
C. Delaware, Lackawanna & Western Ry.

Stresses

The unit-stresses employed in turntable design range from 8000 to 16,000 lb. per sq.in. tension, and from 4000 to 10,000 lb. shear. In the case of the higher figures, impact is added to the live-load stresses.

The committee recommends 10,000 lb. for tension, its equivalent for compression, and 6000 lb. for shear, and believes that with these stresses it is unnecessary to add impact except at the ends, and here 100% impact should be allowed for.

Deflection.—The deflection of turntables must be carefully limited by the design. It is necessary that the loaded table should clear the circle rail in order that by balancing the engine the entire load may be carried at the center and thus the frictional resistance to turning minimized. Allowing ¼-in. clearance between the end wheels and the circle rail for the loaded table, a deflection of ½ in. at each end will make the unloaded table have its rail ¾ in. above the approach rails. This is considered a limit, and the committee, therefore, recommends that the table should not deflect more than ½ in. under load.



Foundation and Pit Wall

The foundation of the center bearing is universally made of concrete. Reinforced concrete is used where a shallow foundation is necessary. The question whether or not piles should be used is determined by the subsoil. The general desire is to have a foundation supported on rock or hardpan, and if these materials or their equivalents are not found at the footing level piles are used. Loadings of 5 to 12 tons per pile are used, the total number of piles being 25 to 49 under footings from 10½ to 16 ft. square. Usually the whole depth of the foundation block is below the level of the pit floor.

The circle wall is now universally built of concrete, although many old tables with timber or cut-stone circle walls still

*The committee report contains a useful collection of diagrams of engines, giving wheelbase and balancing length for tender light and loaded. Nineteen engines are represented in this way, including the 24-wheel Mallet. A table of wheelbase and balancing length is also given in the report.

exist. The foot of the concrete circle wall is extended inward 3 to 5 ft. and supports the circle rail (see Fig. 4). The concrete is carried down to a depth depending upon the nature of the soil, and if necessary is founded on piles.

The circle rail is often bedded on the concrete direct, or on tie plates or an imbedded rail or I-beam, thus giving rigid support. More general practice, however, employs short radial wooden ties as a support for the circle rail. These ties are often either wholly or partly bedded in the concrete. It is considered desirable to keep the base of rail well above the concrete, to allow free drainage of the space between rail and circle wall and prevent the accumulation of snow and the formation of ice in this space. Any tendency to accumulate water in this space has in many instances been found to produce lifting of the rail and its supports by ice forming underneath.

The committee recommends that the circle rail be supported by short creosoted radial ties, about 15 in. c. to c., opposite the main track and 24 in. apart elsewhere, with the use of tie plates and (where available) screw spikes. The concrete between the ties should be sloped inward to drain to the pit.

The circle wall is sometimes designed of such a section as to be able to act as a gravity retaining-wall. The committee recommends that the arch effect of the full circle be taken into consideration and the wall made suitably lighter for economy. A recess, and a pit below, should be formed at one point of the circle wall to give access to the end of the table for inspection or repair.

The rails of the approach track resting on the top of the circle wall are sometimes supported by cast-iron chairs, by steel tie plates, by embedded rails or girders, etc. Other roads use a timber under the rails of the circle wall for cushioning. The committee considers this latter to be the proper practice; the timber should be not less than 8 in. thick by 12 in. wide at the narrowest point, and should be anchored to the concrete, and tie plates should be used.

Turntable Centers

Roller-bearing centers with conical rollers are used on a large majority of railways. Most of them use the standard roller-bearing centers made by turntable manufacturers or bridge works. A number of important lines, however, use roller centers of their own design (A. T. & S. F., C. R.R. of N. J., C. M. & St. P., C. M. & P. S., Erie, L. V.).

Disk centers are used by some important railways (B. & M., C. & N. W. for light tables only, C. B. & Q., N. Y. C. & H. R., M. C., C. C. C. & St. L.). The New York Central Lines had the subject of turntable centers investigated by a committee some time ago and the resulting report recommended disk centers, which, since that time, are standard on these lines. The C. B. & Q. has had entire satisfaction from disk-bearing centers (in three years' experience), and previously found that cone roller bearings will not stand up under heavy loading.

Trouble has been reported both with roller centers and with disk centers. Trouble with roller bearings appears to have resulted from using centers too small for the load (usually because the roller diameter or total roller length was insufficient), from skewing of rollers (due to lack of guidance by a live-ring) from outward displacement of rollers with the result that load was concentrated on a smaller number of rollers, etc. It appears that by suitable design roller bearings can be made wholly satisfactory. The use of ball bearings at the ends of the rollers to take the end thrust and hold them in place has on several roads given rise to trouble. The Erie, for example, reports trouble with such thrust bearings under heavy loading, and has substituted disks for the balls at the end of the rollers. The St. Paul uses a ball bearing at the inner ends of the rollers (see sketch B in Fig. 5) and appears to find this quite satisfactory.

Trouble with disk centers seems to be more common than trouble with roller centers. It is due in many cases to inadequate proportioning, so far as can be judged. The use of disk centers for swingbridges (e.g. sketch E in Fig. 5), carrying very much heavier load than comes on turntable centers, indicates that the disk center is not restricted to light load, but may be used with perfect success under very heavy loading. There is less tilting action on a swingbridge, however, than on a turntable center.

A disk center consists of a lenticular disk of phosphor-bronze between two hardened-steel concave disks, the radii of bronze and steel faces being slightly different so as to give about $\frac{1}{32}$-in. clearance at the edge when the middle parts are in contact. When the load on the center exceeds about 6000 lb. per sq.in. of disk surface, the bearing is apt to seize and cut.

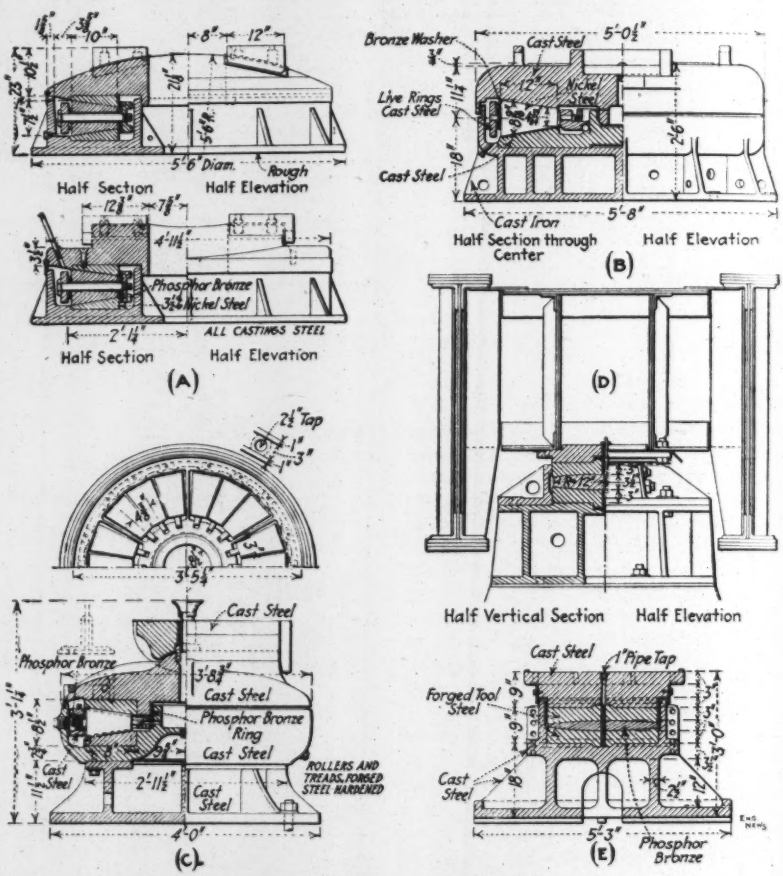


FIG. 5. TYPICAL CENTER BEARINGS

A. Standard 500-ton Turntable Centerof A., T. & S. F. Ry.
B. Standard Turntable Center of C., M.& St. P. Ry.
C. Standard 310-ton Turntable Centerof Penna. R.R.
D. Disk Center for 80-ft. Turntable, C.,B. & Q. R.R.
E. Disk Center for 1000-ton Swing-bridge, Mo. Pac. Ry.

Fig. 5 herewith reproduces several designs given in the report as typical. Three roller centers (A. T. & S. F., C. M. & St. P., Penn.), one turntable disk center (C. B. & Q.), and a much larger swingbridge disk center (Mo. Pac.) are shown. The roller centers shown represent relatively heavy design.

The committee reports that the distinct success of disk centers on certain railroads, the good service obtained from disk centers under the very much heavier loads of swing-bridges, and the fact that disk centers are cheaper than roller centers, entitle them to serious consideration in determining the center to be adapted for a turntable.

Power

The most common power for turntables (other than hand-operated) is electric power. It appears to be preferred universally for all locations where current can be obtained. Air motors are used successfully, though some roads report trouble from freezing; one road recommends that the air pipes be placed underground to reduce freezing troubles, and one road states that care must be taken in arranging the drainage so as to avoid freezing.

Gasoline motors are used on one or two railways, but at least one of these uses them only where air and electric current are unavailable, and objects to gasoline on account of the fire risk.

One railway recommends placing the collector ring for the electric current overhead, as there has been trouble from moisture causing short-circuits and ice in the turntable pit affecting the collector rings below the table.

Steam tractors are used on a few roads.

The committee report does not discuss the arrangement of the operating machinery in detail.

Other Details

Pit Paving—For standard installations at important points, the practice of paving the pit floor is almost universal. Concrete and brick paving are in use. One important advantage of a paved floor seems to be that the pit will be more likely to be kept clean. However, a 6- to 8-in. layer of gravel or cinders will provide an absorbent surface and will prevent the occurrence of mud, and will save a considerable item of cost as compared with a paved floor.

Pit Drainage—Turntables are frequently in trouble on account of insufficient drainage, as the bottom of the pit, especially with the deep pits required by the present-day long table, is apt to be near the drainage level of the neighborhood. Catch-basins and drains should be provided in nearly every case, of course, but when reliable gravity outflow cannot be had the question of building a sump and providing an ejector pump should be considered. This arrangement is used in only a few places at the present time.

Troubles arising from unsatisfactory drainage of these pits are the chief reason for the tendency toward the use of the through type of turntable.

Table Flooring—Turntables are floored with the standard open-tie floor. In a few instances the middle portion of the floor over the turntable is planked. Derailed engines damage the floor so frequently that a planked floor cannot be depended on to keep in shape very long or to remain tight.

A footwalk is usually provided on one or both sides of the floor. This is commonly carried on occasional long ties. The floor is then 14 to 16 ft. wide overall. Railings are rarely provided.

End Locks—Locks to hold the table in alignment when set for a given track are used rather generally with hand operation. Power-operated tables are frequently not fitted with locks, but are held only by the brake of the tractor. The committee approves this practice and recommends that locks are unnecessary where tractors are used.

The locks in use are of various forms. In many cases the lock is applied at the rails, a wide bar being slid out to fit between the rails. Other forms are: A notched chair on the approach, engaged by a hinged bar fastened to the end ties of the table; sockets fastened to the abutment between the approach tracks engaged by a bar sliding out from the table; and similar devices. The committee gives no preference to any one form, but suggests that the simplest appliance is satisfactory.

On a few railways the lock is connected with the lever of a dwarf semaphore attached to one of the girders as a signal, following bridge practice.

Frogs—Most railways lay out their standard tables with approach tracks so spaced that the rails of adjoining tracks do not cross, i.e., no frogs are required. On a small number of railways, however, frogs are used regularly at the larger roundhouses. Frogs are sufficiently objectionable that they should be avoided where possible in an important layout.

Wye Tracks—For abnormally long engines, wye tracks should be used for turning, and roundhouses should be arranged so that some of the stalls can be reached from the wye without crossing the table.

Experiments on Impervious Concrete were made at Husum, Germany, recently in connection with preparations for the construction of a new lighthouse. Various mixtures of cement and fine dune sand in ratios 1:1 up to 1:6 and mixtures of 1:3 with the addition of various waterproofing material such as soft soap, oil and patented mixtures were prepared and were molded into pot-shaped vessels about 15 in. high, with 2½-in. walls. When these pots had set, some of them were filled with water, others (empty) were set into water; and the density of the walls was judged by noting the time required to empty or fill, the water acting under a maximum head of about 10 in. The experiments showed that a satisfactory degree of imperviousness was not reached, since in every test the vessels filled or emptied within an hour. The relative success of the richer mixtures then induced tests of rich rubbed surfacing. To this end the surfaces were first wet, then thickly coated with cement paste, and with a soft brush the cement paste was then rubbed into the surface of the concrete. Repeating this procedure several times until the pores were closed, a very satisfactory imperviousness was reached, the pressure tests (as above) continued for three days showing no water passing through the walls of the pots. On the basis of these tests it was decided to build the lighthouse substructure of a 1:3 mixture with surface made impervious by the grout-rubbing process as used in the experiments. ("Zentralblatt der Bauverwaltong," Oct. 2, 1912.)

Use of Peat Fuel in Russia—The output of peat in the Moscow, Vladimir, Riazan, Kostroma, Nijni-Novgorod, Tamboy and Kazan Governments in 1909 was 1,000,000 tons. In comparison with 1908 this was an increase of 8.3%. Those who have visited the peat bogs in the central industrial district (the Moscow-Vladimir district) can understand the importance of the business. The government of Moscow holds the first place, having contributed about 40% of the whole output in 1909. The second place is held by the government of Vladimir with 30%. Of the 47 firms engaged in working the peat, only six produce it for sale. One firm makes it for its own use and for sale, and the remaining 40 consume their own output. Nine of the latter, in addition, buy a considerable quantity. More than half the output is obtained by the firms from their own bogs and the rest from rented bogs.

Taking into consideration the amounts of crude oil and peat consumed in the central industrial district and comparing with the consumption of Donetzky coal, the following table is obtained:

	1908, tons	1909, tons
Peat	467,742 = 33%	500,000 = 33%
Crude oil.	564,516 = 39%	693,550 = 44%
Coal	403,222 = 28%	355,000 = 23%

From this it is seen that peat holds second place in the region, giving place only to crude oil and exceeding the consumption of coal. In this district the average distance between bogs and mills is about 7.5 miles, and the cost of peat per ton at the mill yard, including transportation, averages $2.25. To correspond with its value, the price of coal should be $5, and the price of crude oil $9 per ton. However, the price of coal was never less than $5.25 and oil $10.50. The natural reserve of peat in these districts is large. The area of bogs in workable shape represents about 29,700 acres and the estimated reserve amounts to 100,000,000 tons.

Tests made by the Moscow-Nijni-Novgorod Ry. with an average peat containing 25% moisture and 5% ash showed 3.19 lb. of water evaporated from and at 212° F. This is to be compared with a figure of 3.9 lb. obtained on the Oldenburg Ry. in Germany. Some Russian cotton mills with mechanical stokers have given 4.46 lb. of water per lb of peat.—From London "Engineering," Nov. 8, 1912.

Canadian Studies of Peat Fuel in Gas Producers and the Elimination of Tar from Producer Gas

The Canadian Department of Mines has issued a report (by B. F. Haanel, Chief of the Fuel Testing Division) giving a record of experiments conducted with peat fuel in a gas producer at the fuel-testing station in Ottawa during 1910-11. It appears that these studies were taken up on account of numerous requests for information concerning the economic utilization of peat. It was then desired only to demonstrate that peat fuel could be economically used in a producer-gas power plant. It has since been found desirable (on account of limited fuel resources) to extend the scope to include testing, on a commercial scale and in a commercial producer, of the bituminous coals of the extreme eastern and western provinces and the lignites of Manitoba, Alberta, and Saskatchewan.

TESTING-STATION EQUIPMENT — After study in America and Europe two producers were purchased, one particularly for peat and the other for bituminous coals. The present equipment of the Ottawa testing station comprises (1) a 60-hp. double-zone Körting peat gas producer with a wet-coke scrubber, tar filter, and a dry scrubber, (2) a Westinghouse 100-hp. suction bituminous producer, complete with exhauster, wet scrubber, gas receiver and moisture separator. There is also (3) a 60-hp. four-stroke cycle, single-acting Körting gas engine; load is secured from a 50-kw. direct-current Westinghouse electric generator direct-connected to the engine, and feeding a bank of resistance grids and incandescent lamps. For starting up the peat producer, a small exhauster is driven by a 1-hp. motor, and an air tank with a 3-hp. motor and compressor is used for starting the engine. A small crusher is driven by a direct-current motor in a near-by shed where peat blocks, as received from the bog, are crushed to the sizes more suitable for the producer. At one end of the producer floor is a chemical laboratory provided with apparatus for complete gas analyses, fuel analyses, and calorific determination. There is a Junkers continuous calorimeter in the engine room close by the gas main for determining the calorific value of the gas.

PEAT GAS PRODUCER—The peat gas producer, shown in Fig. 1, consists of a rectangular steel shell 2 ft. 9 in., by 5 ft. 2 in. in horizontal section and 15 ft. high. There are 12 doors provided for cleaning fires and removing ashes. There are two combustion zones, one at the top and one at the bottom. *F* represents inclined grate bars; *D*, doors for poking and cleaning the upper fire, resting on the grates *F*. Ashes from this combustion zone drop through the grate into the chambers *Z*, from which they are removed through the doors *E*. Gases evolved at this zone are drawn off through the chamber *B* and here the dust and tar are caught (and later removed through a door *P* on the back of the producer). *A* represents the charging hoppers. The grate bars of the lower combustion zone are shown at *M*, and at *I* a door through which these fires are poked and cleaned. The fire above the grate is poked through the doors *Q* and the ashes from the complete combustion of the fuel fall through the grate bars into the chambers *O* to be removed through the doors *J*.

Products of combustion from the upper zone are drawn off through *B*, and led along the pipe *C*, and down the vertical pipe *V* to a chamber *K*, where they finally pass through the fuel of the lower zone to the two gas off-takes *H*.

At *S* on the top of the vertical pipe *V* is a damper which is open to allow gases resulting from combustion of the peat (upper zone) to pass into the atmosphere, when the producer is standing idle; the damper *T* is also then closed, but it is opened and the damper *S* closed when the producer is in operation. The vertical pipe *V* is cooled by a cold-water jacket. At *W* is a water seal which covers the open bottom of the vertical pipe.

To secure a cool, clean gas delivered to the engine the product of the producer had to be passed through a cleaning system composed of a wet-coke scrubber, a tar filter, and a dry-excelsior scrubber. After leaving the producer the gas entered the wet-coke scrubber at the bottom and passed upward through about 3 ft. of closely packed coke, which was continuously sprayed with water. In this scrubber the hottest gases came in contact with the warmest water, and finally passed off at the top through the coolest spray. Here the gas gave up the greater part of its sensible heat, its dust, and some of the tarry matter in suspension. From the wet-coke scrubber, the gas went through a tar filter composed of a number of baffle-plates around which the gases passed before finally leading through four perforated metal plates. The baffle-plates and the perforated plates were washed by sprays of hot water, obtained from the return cooling water of the gas engine; this removed the larger part of the tarry matter carried over from the coke scrubber.

After leaving the dry scrubber and before entering the engine, the gas passed through a receiver, where the moisture still contained in the gas was deposited. The water which collected here was pumped out from time to time, preferably at the end of a week's run.

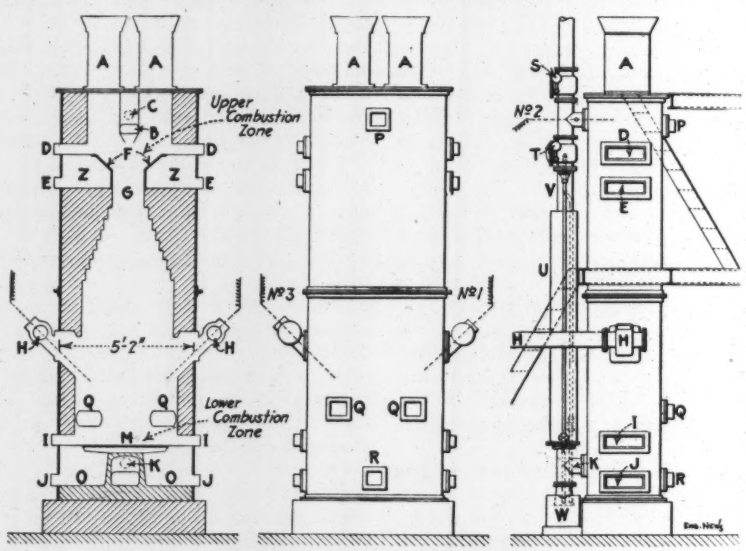


FIG. 1. ELEVATIONS OF THE KORTING PEAT GAS PRODUCER AS FIRST INSTALLED AT THE OTTAWA TESTING STATION

When the producer is in proper operation, that portion between the lower grate bars *M* and the upper grates *F* is completely filled with peat coke. The portion between the upper grates and the top of the hoppers is filled with raw peat as it comes from the shed. The function of the upper zone is to drive off moisture and volatile matter from peat which goes to the lower grates. The combustion here is just sufficient to supply the heat necessary.

To prevent the products of this partial combustion from being drawn, by the suction of the exhauster or gas engine, straight down through the producer and out through the off-take, instead of having first to pass up through the incandescent fuel in the lower zone, a narrow neck was made in the firebrick lining, as shown in Fig. 1, just below the upper zone. With the producer entirely filled

with peat coke to the upper grate, the resistance offered to the passage of the gases through the contracted neck was greater than that offered to the passage of the gas through the chamber *B*, pipes *C* and *V*, chamber *K* and then up through the incandescent carbon bed to the off-take.

Some of the moisture and tarry vapors are condensed on the water-cooled surface of the pipe *V* and drop to the bottom of the water seal, from which the tar can be readily removed. That portion of the water and tarry vapor which escapes is drawn up through the incandescent coke and off through the gas uptake. A portion of the escaping moisture is decomposed to H and CO_2 by reaction with the hot carbon; part of the CO_2 is reduced to CO and some of the tarry vapors are changed to stable compounds. The gas from the upper zone by analysis has been shown to be about 15% CO_2, 7% CO, 3% O_2, and 0.7% C_2H_4 with the residue of nitrogen.

Care was taken to ascertain the most suitable size for crushing the peat. This was necessary since the fuel passes through the upper zone in comparatively short time and the process of coking must be rapid. If the peat was wet or not crushed small enough, it reached the lower zone only partially coked and with only part of its moisture evaporated. Under these conditions is was impossible to obtain a gas sufficiently free from tar for use in the engine.

In starting up fresh, a wood or coke fire was built on the grate bars of the lower zone. When this was well underway, peat was slowly fed into the hoppers, time being allowed for the peat to become thoroughly heated before a new charge was put in. In this manner the producer bed was slowly built up until the grate bars of the upper zone were passed. A fire was now built under the grate bars of the upper zone; when this was well under way, the hoppers were completely filled.

PRELIMINARY TESTS—Previous to the erection of the Ottawa station and the installation above described, the Mines branch undertook the manufacture of peat at the Victoria Road bog, near Lindsay, Ont. About 70 tons were manufactured and stored under cover for more than a year, awaiting completion of the Ottawa plant. This peat was shattered in handling before being stacked at the station and needed no crushing.

Three tests were made under varying conditions to determine the fuel consumption per brake horsepower, but as the general testing equipment, chemical laboratory, etc., had not been installed, the gas was neither analyzed nor metered. Load carried on the engine was determined by voltmeter and ammeter readings at 15-min. intervals. Efficiency of the electric generator entered into calculation for brake horsepower of the engine. Weight of fuel charged in the producer during tests was not determined hourly, but the amount required to fill the producer hoppers whenever charging was necessary was totaled at the end of the tests.

It was found that the duration of tests needed not to be longer than 7 hr., since the fires of the upper and lower zones could be readily cleaned of ashes; since the part below the upper grate level is always filled with peat coke, it was possible to bring the producer, after a 7-hr. run, to nearly the same condition and weight of fuel bed—provided the producer was run for two or three hours before the beginning of the tests. Most tests, however, were run for at least 10 hr.

Owing to its long storage, the peat was too dry to work well in the Körting producer, which was not provided with an evaporator for steam raising. Analysis of the cleaner peat showed 69.5% volatile matter, 25.2% fixed carbon, 5.3% ash, 13% moisture, and a calorific value of 8652 B.t.u. This peat was taken from a shallow part of the bog underlain by sand, and consequently the average percentage of ash was higher, running to 10%. This, with the excessively high internal temperature due to dryness of fuel, caused some trouble in the preliminary tests from the formation of clinkers which could not be easily broken up. These could have been avoided had there been provision for introducing steam. Cavities formed in the first test (see Table I) and caused irregularities in gas composition and excessive tar. During the second test to correct the excessive dryness of fuel, water was admitted to the lower fire-doors and most of this found its way to the ashes in the chamber below the grate bars. This helped operation somewhat, but was not a sufficiently effective way of introducing moisture.

In the third trial, the producer was poked only at the beginning and end of the run, water being introduced as before through the lower firing doors. The producer was charged whenever the fuel in the hoppers dropped to a certain level. During the first 5 hr. the fuel consumption was irregular, due to the presence of clinkers from the previous day. During the last 5 hr. the consumption was uniform. The data from these tests is summarized in Table I.

After the completion of the chemical laboratory, tests were begun with peat from the government plant at Alfred.

TABLE I. PRELIMINARY RUNS WITH PEAT GAS PRODUCER.

Test No.	Hours duration	Engine b.hp.	Fuel Ash %	Fuel B.t.u.	Fuel H_2O %	Lb. per b.hp. hr. as fired	Lb. per b.hp. hr. dry
1	7½	58.9	10	8650	13	2.04	1.78
2	12	58.0	10	8650	13	2.45	2.12
3	10	61.8	10	8650	13	1.99	1.73

Considerable time was spent in ascertaining the size to which the peat should be crushed to obtain best results. It was found that peat containing 30% moisture should be crushed to about the size of a hen's egg, while with peat containing less moisture larger sizes could be used. The smaller sizes offered no difficulties regardless of the moisture contents.

A fourth trial was made at full load for 30 hr., so that fuel consumption, uniformity of gas, water consumption for cooling and general behavior could be observed over a longer period. The producer had been standing idle for some time and was comparatively cold when the trial commenced. During the first 10 hr. considerable tar was carried past the cleaning system into the mixing and admission valves and the cylinder. However, no trouble was experienced which necessitated a reduction of the load, since the tar was found completely soluble in a mixture of oil, soap and water. At the termination of the trial the producer was in excellent condition and the gas contained but little tar. The plant could have been operated continuously for almost any period. The lowest heating values always occurred immediately after poking, but the heating value never dropped low enough to necessitate a change in proportion of mixture of gas and air at the engine. Further tests were made at what were attempted to be full, three-quarter, half and quarter load, to determine the load of best operation. The gas was sampled and analyzed and the temperature taken at off-take. Water for producer system and also for the engine was measured. The results are summarized in Table II.

FAULTS OF PRODUCER DESIGN — The trials previously described showed that with the producer and cleaning system in place it was impossible to obtain gas sufficiently free from tar to permit steady operation of the engine without cleaning the cylinder and valves. The cleaning of the engine could usually be done running and without interfering with the load, but the plant could not be run for an indefinite period without having to shut down.

Many experiments pointed to a faulty

TABLE II. FULL AND PARTIAL LOAD RUNS WITH PEAT GAS PRODUCER.

Test No.	Hrs. duration	Engine b.hp.	Fuel H_2O %	Fuel Ash %	Fuel B.t.u.	lb. per b.hp.-hr. as fired	lb. per b. hp.-hr. dry	Temp. gas F°	Calorific value Gas	Producer water gal. per b.hp.-hr.
4	30	58.2	29.3	6.0	9470	2.81	1.98	.....	116	3.61
5	10	53.6	33.3	6.4	9440	2.95	1.96	430	118	5.9
6	10	32.8	31.8	6.0	9440	3.25	2.21	232	122	10.31
7	10	60.1	35.0	6.1	9500	2.59	1.68	447	117.5	4.98

construction of the producer itself, and changes in internal construction were recommended to Körting Brothers, of Hanover, Germany. Later, 10 tons of peat from the Alfred bog was sent to the Hanover works.

ALTERATIONS—The makers found it advisable to alter the shape of the lining of the producer, since the contracted neck described before (Fig. 1) did not offer sufficient resistance to the direct passage of gas down to the off-take instead of by the normal path. The neck was made longer to increase resistance to passage of gas downward, as shown in Fig. 2. The increased thickness of lining was taken advantage of for decreasing loss of heat through radiation. The lining is of silica brick at *a*, firebrick at *c*, and a "specially prepared insulating material" between *a* and *c*. The gas offtake from the upper zone was enlarged.

By this reconstruction it is probable

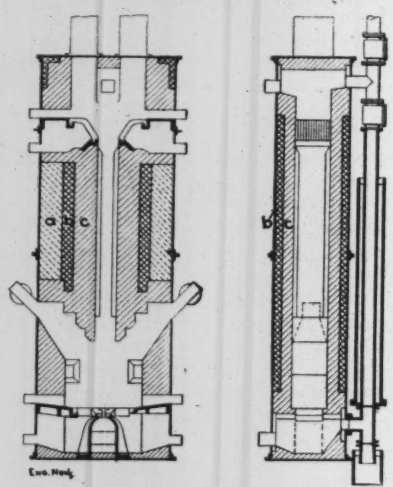


FIG. 2. MODIFIED KORTING GAS PRODUCER AT THE OTTAWA STATION

that very nearly all of the gases from the upper zone were led to the chamber under the grate of the lower zone. Burning of the tarry vapors or their splitting up into permanent gases was realized to a certain extent, but yet a certain quantity of vapor still escaped combustion or decomposition, and had to be separated out in the cleaning system. The manifest improvement was especially in uniformity of gas, and in the amount of solid material, of high-heating value, separated out in the coke scrubber.

Certain alterations were then made by the builders to the wet-coke scrubber, consisting of an addition to the top of the old scrubber which was used with original plant. This is seen in Fig. 3; the lower part of the modified scrubber consisted, as before, of a gas chamber connected by an overflow pipe *E* to a water seal, and having a cleaning door *H* and a gas intake *D*. The middle part *C* was filled with coke, resting on wooden gratings at *F*, and fitted with a cleaning door at *G*. At the top of the old section, immediately above the coke, is a settling chamber which formerly served as a gas outlet and in which was then placed the water spray. The additional length added to the old scrubber was 5 ft. high. On the lower end of the cylinder was a diaphragm plate *S*, in the center of which was a 12-in. hole. A perforated metal plate covered this hole and the cylinder *K*, open at both ends and perforated to about ⅔ of its height, was fitted inside a flange on the perforated plate *J*. *L* is the water spray, and *N* a relief cock.

Gas from the producer entered at *D*, passed up through the grating *F* and the coke *C* into the expansion or settling chamber *R*, thence through the perforated plate *J* and the perforations in the cylinder *K* to the outlet *M*. The spray at *L* impinged against the interior surface of the cylinder *K*, ran down and passed through the plate *J* and the coke *C* to the bottom of the scrubber, where it flowed off through the pipe *E*.

The gas in passing through the wet coke was cooled and lost some of its dust and tarry matter, which passed with the cooling water into the seal. In passing through the perforated plate *J* the velocity of the gas and consequently the particles of tar carried past the coke was increased, so that when the gas again expanded into the chamber surrounding the cylinder *K*, its velocity and that of the tarry products was reduced. Some of the latter adhered to the inside and outside surface of the cylinder, or dropped to the bottom on the metal plate *J* and were washed down to the overflow.

Considerable improvement in the cleaning was secured in this way, but the particles which were carried through in suspension were not affected by the alternate increase and decrease of gas velocity. They passed through the entire system to the engine and finally condensed on the walls of the mixing and admission valves and in the cylinder itself. The alterations to the original coke scrubber were, on the whole, not sufficient.

A change in the coke scrubber was developed by the chief of the fuel-testing division, B. F. Haanel, after experimental studies on the deposition of the tar in suspension, and a number of service runs.

The lower part of the coke scrubber was not altered, but finally the cylinder *K* (Fig. 3) and the perforated plate *J* were removed and in their place was substituted, as shown in Fig. 4, a 40-mesh brass-wire cone. At *C* an overflow was provided for carrying away the solid matter separated from the gas on the outside of the cone and washed off by the spray *G*. A fine spray *B* served the combined functions of washing the interior surface of the cone and cooling the gas. At *F* a water jet was provided for sluicing the overflow pipe *E* whenever this clogged, but it was never found necessary to use it. The water spray *G* which, in the old system, had been supplied with cold water only, was now connected by a two-way cock to the return cooling water from the gas engine. Whenever the suction in the chamber containing the wire mesh began to rise, the cold water *G* was shut off and hot water turned on. By this means the suction could be brought to normal in about a minute. This cleaning was found necessary only two or three times during a 10-hr. run.

With this arrangement, gas now passes

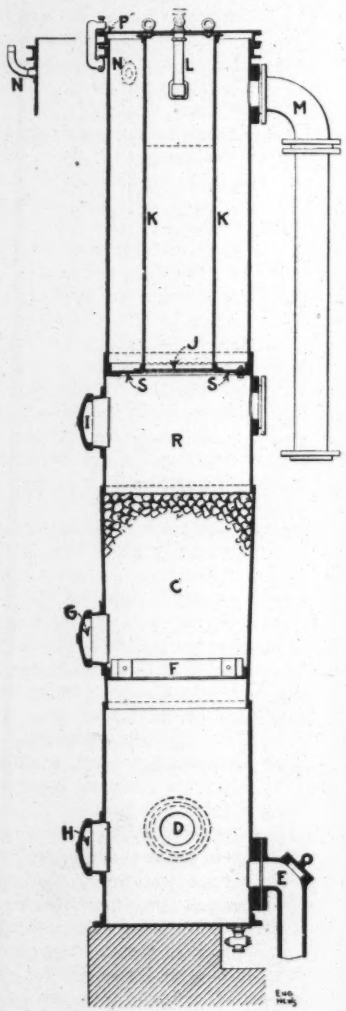


FIG. 3. KORTING MODIFICATION OF WET-COKE SCRUBBER

through the wet coke into the chamber *R* as before. From here the cooled gas is run through the opening *O*, through the cone screen and passes out at *M*. In passing through the screen, some of the particles of fog carried by the gas impinge against the metallic surface of the cone, aggregate into comparatively large drops and are washed off by the continuous spray *B*, dropping into the chamber *R* and going down through the wet coke.

Particles escaping contact with the metallic surface of the cone in passing through the fine meshes are crowded together, coalesce and form larger drops which either adhere to the outside surface of the cone or drop to the bottom. The continuous cold water spray *G* washes the tarry matter into the overflow.

Gas after leaving this cleaning system is clean enough to be used in the engine without any trouble whatever. Close and careful regulation of the producer is not as essential to the cleanliness

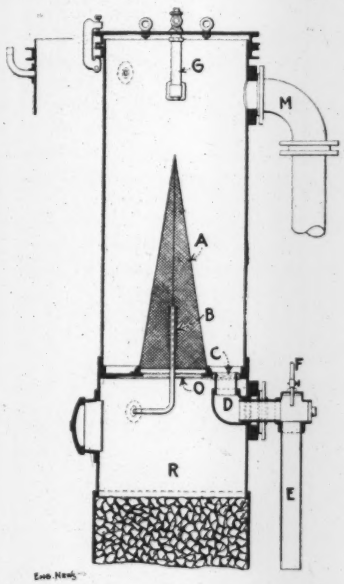


FIG. 4. HAANEL MODIFICATION OF WET COKE SCRUBBER

of the gas leaving the cleaning system as it was with the older construction.

On completion of the builder's alterations to the producer and cleaning system, 26 service trials were carried out, 14 of which are described in detail in the report. From this number a few of the more important are here considered.

Trials Nos. 20 and 21, data for which are shown in the accompanying table, were the first after reconstruction of the producer and manipulation was left to the builder's representatives. Owing to tar in the engine cylinder, two washings with the oil-soap-water mixture were necessary in test No. 20 and four in test No. 21 to stop pounding.

For trial No. 24 at ⅔ load, peat from a commercial company in Farnham, Que., was used. This was of good quality with 29.9% fixed carbon, 65.1% volatiles, 27.8% moisture, 5% ash, and a calorific value of 7020 B.t.u. It was found that the excavating machine of this company brought up with the bog peat some underlying partially decomposed rock carrying iron. This passed through the macerator and entered into the finished peat. In the producer the ferruginous rock formed bad clinker at high temperatures.

In trial No. 29 the gauze cone was in place, but inside the perforated pipe added by the builders. The cone was washed only with the cold-water spray at the top. It was found at the end of the test that an attendant had carelessly stopped the standpipe between the upper and lower zones; the gases from the upper zone were therefore forced down through the narrow center shaft to the off-take and were neither burned nor split up before reaching the scrubber. Yet, due to the action of the cone, there was no trouble in the engine cylinder or valve. The cone tended to clog from tar on the inside and the second spray was added. The air openings under the lower zone for this test were set at 2.8 sq.in.

For trial No. 31 the air opening under the lower zone was thrown wide open (3.3 sq.in.). Gas from the upper zone burned beneath the grate of the lower zone. Wash-water from the coke scrubber carried a yellow solid material. The engine ran well, but it was necessary to clean the valves at the end of the run.

For trial No. 32 the air holes below the lower zone had been enlarged to 4.1 sq.in. On account of the water demands of the station's ore-concentrating laboratory, there was an insufficient supply for engine and producer, causing high suction. Gas from the upper zone burned under the lower grates; the coke-scrubber wash carried a light brown solid material, but less in quantity than the solids from trial No. 31. The cylinder and valves were in good condition at the end.

For trial No. 33 the air holes under the lower zone were enlarged still more (to 5.1 sq.in.). The results were much the same as in test No. 32 except that the material collected by the gauze cone gathered between the cone and perforated cylinder, inclosing it.

Before trial No. 35 the coke scrubber had been permanently altered to the form shown by Fig. 4. The perforated cylinder was removed and the gauze cone fitted to a ring and clamped over the hole in the diaphragm plate between upper and lower compartments. The hot spray was also added and an overflow for carrying the material discharged off the cone.

During the first 3½ hr. of trial No. 35 the openings were restricted to 2.2 sq.in. and for the rest were increased to 3.3 sq.in.—the normal full-load figure. This increase of area was accompanied by a reduction of suction pressure and gas temperature at the upper zone. The calorific value and final temperature of gas at the off-take were increased; CO_2 and H_2 were decreased while CO was increased. The engine finished the run with clean valves and cylinder.

For trial No. 36 the air openings were for 4.1 sq.in. No trouble was experienced from tar. The more important data of these trials are gathered together in Table III.

The report presents the general conclusion that the peat producer-gas plant at Ottawa is now thoroughly reliable and that its operation may be continuous for a week or more without shutting down for cleaning the engine valves. The operation of the producer is uniform and gas varies only slightly in quality during a 10-hr. run. Removal of ashes and cleaning of the fires can be done without interfering with the engine's operation or changing materially the quality of gas. It is held that a plant of the size installed in the station can safely be left in the hands of an intelligent laborer after he has received instruction from a competent engineer for a week or so in handling the plant. The services of only one man are required to run the plant for a single day shift.

If the pipe leading from the producer to the cleaning system and the tar filter are cleaned once the week when the plant is run 10 hr. a day, then little other work is required to keep the plant in good condition.

The average normal consumption of fuel per brake horsepower-hour, including standby losses, has been, for full load, 1.7 lb. of dry peat or 2.3 lb. of peat containing 25% moisture. For three-quarter load, the figures are 2.1 and 2.8, respectively.

The World's Supply of Nickel comes practically all from Canada, which produces 90% of the total. Most of the remaining 10% is produced in New Caledonia, a French island in the southern Pacific. The only refineries are in the United States. In 1910, the value of nickel refined from Canadian ores amounted to 12 million dollars.

TABLE III. TRIALS OF REMODELED KOERTING PEAT GAS PRODUCER.

Test No.	Hrs. Duration	Engine hp.	Fuel H_2O %	Fuel Ash %	Fuel B.t.u. per lb.	lb. per b.hp. as fired	lb. per b.hp.-hr. as dry	Gas Net Cal. val.	Gas Temp. offtake F°	Producer water gal. per b.hp.-hr.
			Alfred peat							
20	10	53.8	31.4	5.7	6500	2.32	1.60	113	469	....
21	20	53.7	30.2	5.4	6600	2.27	1.60	120	475	....
			Farnham peat							
24	10	41.3	27.8	5.0	7020	2.66	1.91	129	621	10.4
			Alfred peat							
29	8	45.7	23.1	4.9	7270	2.82	2.16	130	660	....
31	8	46.9	23.5	4.7	7270	2.81	2.15	124	727	....
32	8	46.2	23.5	4.7	7270	2.53	1.93	130	755	....
33	8	45.8	22.2	4.8	7310	2.27	1.77	138	750	....
35	8	45.9	22.2	4.8	7310	2.33	1.81	127	742	....
36	8	45.8	22.2	4.8	7310	2.62	2.03	134	820	....

Letters to the Editor

More Long-Span Combination Bridges

Sir—I note Mr. Chandler's letter concerning "Long-Span Combination Highway Bridges" in your issue of Nov. 7, 1912, p. 873.

I personally built the longest on the Pacific Coast up to 1896 and as follows:

Eel River, Calif.:

Combination span, 360 ft., center to center of end pins.
Center depth, 60 ft.
Width of roadway, 18 ft.
Compression members and floor of Douglass fir.
Tension members of Edgemoor steel eye-bars.

Rogue River, Ore.:

Same as Eel River bridge except of 4 ft. shorter span.

Frazer River, at Lillooet, British Columbia:

Combination 3-hinge arch, length center to center of hinges, 340 ft.
Same materials as above.

The polygonal trusses over the Eel and Rogue Rivers are figured for compression in the end bottom chord eye-bars at 30 lb. wind pressure, and through the entire bottom chord there are wedge tightened struts to take the stress in the bottom chord treated as the compression member of the horizontal wind truss.

I mention these things to show that although commercial conditions required the use of timber for compression members, we adopted a high grade of bridge engineering in all other matters pertaining to design. Extreme boldness in the adoption of light loading was frequently necessary to construct any structure at all within the limits of county bridge funds; but county authorities were always notified of load limitations and the fall of the combination highway bridge in Victoria, B. C., many years ago under a crowded 30-ton trolley car was due to allowing trolley traffic upon a light highway bridge originally built for a capacity of only 1000 lb. live load per lin.ft.

H. S. WOOD,
Consulting Engineer,
1825 Park Row Bldg.,
New York City.
Nov. 8, 1912.

Rectangular Engine-Houses

Sir—In your issue of Oct. 24 there is a very interesting description of a rectangular engine house with ladder-track approaches, which is being built by the Missouri, Oklahoma & Gulf Ry. at Muskogee. The editorial in the same issue shows that railway men generally are evincing a growing interest in the undoubted merits of this class of building.

I submitted a detail floor plan for a building of somewhat similar design to the American Railway Engineering Association at the Chicago convention in 1905, and there was considerable discussion on this. A drawing of my design appears opposite page 688 in the *Proceedings* of that year, and the discussion is on pages 687 and 688 of 1905, and page 640 of 1906. I inclose prints of the design for a 19-stall and a 38-stall engine house, in case the matter may be of interest to your readers.

D. MACPHERSON,
Assistant to the Chairman,
Commissioners of the
Transcontinental Ry.
Ottawa, Ont, Canada, Nov. 8, 1912.

[The special feature of Mr. MacPherson's design is the use of crossover connections (with plain and slip switches) between the engine tracks, so arranged with reference to the engine positions or "stalls" that an engine can reach or leave a stall without the switching of any other engine. Of course this adds to the length of the house for a given number of engines. The accompanying cut shows the plan for a 19-stall rectangular engine house, with interior crossovers and with direct track connections to the yards. A turntable is provided, but so located that it is not in a running track, and is used only by engines which require to be turned. The house is 420x115 ft., with track centers spaced 16½ ft. apart and 8 ft. from the walls. The turnouts are 55 ft. long from switch-point to frog-point and the slip switches 57 ft. 6 in. long. A house for 38 engines is of the same width, but 790 ft. long, and has two plain crossovers and three ladder tracks. The following claims are made for the plan illustrated:

1. In case of fire, all engines in a full shed can be run out of danger in 10 min., even if only seven of them are under steam, as one engine can haul out six others on the same track. It will take an hour or more to empty a circular engine house, even if all engines are under steam, but in such cases something is sure to go wrong, the table may be blocked and most of the engines lost.

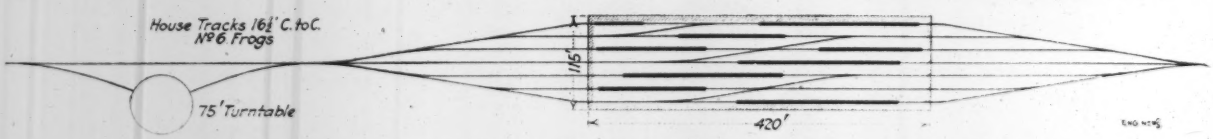
2. Engines going to or coming out of the house do not require to run over turntable, unless in need of turning, thus saving 50% of wear on table. If a Y-track is available, no turntable is necessary for the engine house, thus saving large initial expense, and also wages of men for turning engines.

3. The area of ground occupied or made useless by a complete circular engine house in center of a large yard is a square of 350 ft. sides, which is much greater than with a rectangular shed, the shape of which adapts itself better to a standard layout.

4. A less costly style of building is required, and only 14 doors are necessary, as compared with 40 in a complete circular engine house. As glass in doors is constantly breaking, this is a large saving in maintenance.

5. Ordinary rectangular sheds for more than 20 engines generally have a transfer table, which is more expensive than a turntable, and nearly as slow to operate.

6. Engines are constantly growing in length, necessitating abandonment or enlargement of old circular sheds and turntables. In rectangular sheds it is only necessary to extend building and rearrange diagonal tracks.—ED.]



DESIGN FOR RECTANGULAR ENGINE-HOUSE WITH INTERIOR CROSSOVERS AND LADDER TRACKS TO FACILITATE ENGINE MOVEMENT

(The stalls or engine positions are indicated by the heavy black lines on the house tracks.)

Notes and Queries

Ransome concrete mixers were used in building the new south pier of the Quebec Bridge. Our article on this work in our issue of Nov. 7, 1912, p. 855, stated erroneously that Smith mixers were used. The mistatement was due to an inadvertence on the part of the engineer who furnished the information on which the article was based, and this correction is made on his authority.

Issued Weekly by the
Hill Publishing Company
JOHN A. HILL, Pres. ROB'T MCKEAN, Sec'y.
505 Pearl St., New York.

Monadnock Bldg., Chicago.
6 Bouverie Street, London, E. C.
Unter den Linden 31—Berlin, N. W. 7.

CHARLES WHITING BAKER, Editor.

Subscriptions payable in advance, $5.00 a year for 52 numbers, including postage in the United States, Mexico, Cuba, Porto Rico, Hawaii, or the Philippines, $7.00 in Canada.

To foreign countries, including postage, $9.00 or its equivalent, 36 shillings: 36 marks: or 45 francs.

Notice to discontinue should be written to the New York Office in every instance.

Advertising copy should reach New York Office by Thursday of week before date of issue.

Entered at New York Postoffice as mail matter of the second class.

CIRCULATION STATEMENT

During 1911 we printed a total of 931,958 copies.

Of this issue 19,000.

None sent free regularly, no returns from news companies, no back numbers.

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*Illustrated.

Engineering News

The real reason why construction work has been suspended on the extension of the Grand Trunk Ry. to Providence, R. I., has at last been discovered. It appears that the draftsmen who are plotting the surveys have not yet been able to spell Lake Chaubunagungamaug. A Welsh draftsman has been cabled for.

There could be no more forceful statement of the rapid development of the United States as an industrial nation than the announcement by the Bureau of Commerce that our foreign commerce will exceed four billion dollars in 1912, whereas it never reached two billion dollars prior to 1899, and only passed the three-billion mark in 1906. While part of the increase is due, of course, to the higher range of prices now ruling, most of it is due to an actual growth in volume of articles bought and sold. The total value of our exports has doubled in the eight years since 1904, and this notwithstanding the fact that we have now a much smaller surplus of foodstuffs to send abroad above our own needs. The growth of exports in the last decade, therefore, is chiefly in manufactured goods.

Alkali as a Preventive of Corrosion

Elsewhere in this issue is printed a brief paper describing the results of experiments to determine the effect of acid and alkaline solutions on the rate of corrosion of iron and steel. Especially noteworthy is the statement made by the author of the paper that as the result of long-continued experiments and experience he finds that a 3% alkaline solution absolutely prevents all corrosion of iron or steel. Weak alkaline solutions were found to produce pitting and the author of the paper, Commander Lyon, presents an interesting electrical theory to explain the action of acid and alkaline solutions of various strengths upon iron.

It is, of course, fairly well known among those who have studied the question of corrosion that any acid solution, even when very weak, may produce corrosion. It is well known how a water-supply coming from a swampy gathering ground and containing a very slight amount of tannic acid and perhaps other vegetable acids in solution will often produce serious results in the corrosion of water mains and service pipes. Cases are on record, also, where an abnormal amount of carbonic acid gas in a water-supply system has caused considerable trouble by corrosion. Alkaline waters, on the other hand, are thought to be generally resistant to corrosion. As an instance may be cited the common machine-shop practice of using a soap or soda solution instead of clear water for the jets used on turning tools.

According to Commander Lyon, however, a weak alkaline solution may, under certain circumstances, be even more harmful than a weak acid solution, since instead of producing general corrosion the corrosive action is concentrated in certain spots and pitting results. Apparently, however, such pitting does not occur until the alkaline content rises above one-tenth of 1%. This represents an alkalinity which would very seldom be found in any natural water. It would not, therefore, be harmful to merely neutralize the acidity of a water which was producing corrosion.

Of course, in water used for domestic supply, prevention of corrosion by high percentages of alkali would not be practicable. There are numerous cases in engineering, however, where it would be quite feasible to prevent corrosion in this way. For example, if in steel water tanks used to store a supply for fire purposes only, corrosion of the metal can be prevented by so simple a means as keeping the water strongly alkaline, it is a fact well worth an engineer's attention. The prevention of corrosion in the interior of a hot-water heating system would also be an advantageous application of this principle.

Paying for the Excessive Use of a Road

Paying for service in proportion to use is a fairly well established principle in most public utilities, but since the days of toll roads have passed it has not had much application to highways. We note, however, that in England there is a modification of the principle in vogue, namely, payment for the *excessive* use of highways. A recent editorial in *The Contract Journal, of London,* refers in the following manner to a court decision which, though it serves to explain the practice to Americans, apparently has tended to confuse its legal status.

The decision in the Hexham County Court in the case of the Billingham Rural District Council against the Darney Quarry Co., West Woodburn, adds to the confusion of the law with regard to extraordinary traffic. There is about a mile of road between the quarry and the West Woodburn Station, which has been used by the company for over six years in carting their stone from quarry to station.

Already, in the early days of the

quarry, the company has paid over £100 as damages for extraordinary traffic, but the Council seem merely to have tinkered with the road, putting on it 3- or 4-in. whinstone, but not making any foundation nor recognizing any need to make the road suitable for the traffic which they knew it had been, and would continue to be called on to bear. Naturally it was repeatedly cut up, whereon they make a fresh claim for damages from the company, and this, it seems, may go on indefinitely. The defendants contended that the road had been neglected, so that even ordinary traffic cut it up, that it was badly repaired—4-in. whinstone certainly seems worse than indifferent roadmaking—and that their regular traffic over the road had by efflux of time become ordinary traffic. The judge held, however, that the traffic was extraordinary, and the company had to pay £40 damages and costs.

We had always understood that the question of whether traffic was ordinary or extraordinary had relation to the permanent local trade conditions. That, in effect, only temporary use, if damaging, could be regarded as extraordinary, and that a regular traffic (if tolerable at all) must be provided for by the road authorities, even though it be only that of one firm.

In these days of road-tearing passenger automobiles and road-breaking automobile trucks there is even in this country a growing feeling that a large part of the cost of road maintenance should be placed where it properly belongs, upon the owners of the machines that are responsible for the high cost of highway maintenance. It is interesting to know that in the longer established highway system of England there is a law, or a custom that is equivalent to law, which in effect establishes a principle from which the more modern application may rationally be deduced.

Methods of High Finance in Good Road Construction

We print elsewhere in this issue a part of the presidential address at the annual meeting of the American Road Builders' Association, this week at Cincinnati, of Nelson P. Lewis, Chief Engineer of the Board of Estimate and Apportionment of New York City. Mr. Lewis emphasizes in the first place that the Association of which he is the head is not carried on for the purpose of booming good-road construction; that work is being done and overdone by others. The danger at the present time, and not a remote danger by any means, is that the current craze for good-road construction will cause the unwise expenditure of many millions of borrowed money by states, towns and counties, and that in the inevitable reaction when the public learns by experience the result of roads improperly financed, improperly built, and improperly maintained there will be a very serious setback to the movement for better highways.

It is almost needless to say to engineers that 90%, if not 99%, of the current literature on good roads appearing in the newspapers is the veriest trash. Those who produce it are in truth blind leaders of the blind, and those who traverse some of the roads built under the inspiration of such guidance are extremely likely to meet the fate predicted in the Scripture and fall into the ditch. The leaders of the engineering profession as a whole will heartily support the sound doctrine laid down in Mr. Lewis' excellent address that where it is necessary to build improved highways with borrowed money, the loan should run for no longer period at least than the life of the improvement which it is to pay for. Issuing 50-year bonds to pay for improved road surfaces, as already authorized in the State of New York to the amount of $100,000,000, means that we are unloading onto the next generation burdens of paying for improvements which will be worn out and gone while that generation is yet unborn.

Mr. Lewis also points out the financial fallacy of building a road better than the tributary population can support. Prominent engineers have at various times pointed out in the columns of ENGINEERING NEWS that the computations of the good-roads propagandists which purport to show enormous benefit to the abutting lands on improved highways as a result of the construction are really fallacious when applied to ordinary farming land.

There will be those who will doubtless say that Mr. Lewis in taking this position is going beyond the proper function of the engineer, that it is merely the engineer's business to take all the money he can get and build all the roads he can with the money, and that it is no part of his business to see that sound economics and safe finance and proper political methods are obtained in road construction. For ourselves we protest against any such limitations of the field of the engineer's work, for the engineer owes a duty to the public and the public will do well to heed the engineer's warning. If there is any other class of men in the community so well able to understand what is sound economics and sound finance in road construction, then its voice has never been lifted in the public defense. We recommend to our readers a careful study of Mr. Lewis' address.

The Prevention of Strikes by Railway Employees

Probably during the year 1912, the seven men who have rendered the greatest public service to the people of the United States are the men who composed the Arbitration Commission between the Eastern railroads and the Brotherhood of Locomotive Engineers.

In March last, as our readers will recall, a deadlock arose between the Eastern railroads and their locomotive engineers who were members of the Brotherhood. The engineers had made demands for certain increases in the rate of wages. The railways had refused to grant these on the plea that their financial condition would not permit the advance requested. A vote of the engineers affected was taken and over 93% of the votes cast were in favor of the declaration of a strike.

It was then within the power of the Grand Chief of the Brotherhood, Warren S. Stone, to have called a strike immediately, but through the exertions of Judge Knapp of the U. S. Court of Commerce, and Commissioner of Labor Chas. P. Neill, both parties to the dispute were induced to submit their differences to arbitration. Each side to the controversy selected an arbitrator, and it was agreed that five other arbitrators should be selected jointly by a committee made up of the Chief Justice of the United States, the presiding judge of the Commerce Court, and the U. S. Commissioner of Labor.

The railroad arbitrator was Daniel Willard, President of the Baltimore & Ohio R.R. The Brotherhood selected as its representative T. H. Morrissey, former Grand Master of the Brotherhood of Railroad Trainmen. The five arbitrators named to represent the public were Hon. Oscar S. Straus, of New York; Dr. Chas. R. Van Hise, President of the University of Wisconsin; Frederick N. Judson, of St. Louis; Dr. Albert Shaw and Otto M. Eidlitz, of New York.

So far as the wage increases asked for are concerned, the decision of the arbitrators may be briefly summarized by stating that it disposes of the controversy by granting the engineers certain increases in their present minimum wage rate, although not so large an increase as they had demanded. There is, of course, no question of the acceptance of the award by both parties to the controversy, and for this service alone the Commission deserves great credit. It has peacefully settled a controversy which, had it been carried to the point of industrial warfare, might have cost hundreds of millions of dollars in destruction of property and might have led to results which no man can foresee.

The Commission's public service does not end here, however. In the months of study it has given to this question it has come to realize how great are the dangers which threaten the public welfare as the result of the rapid progress of combinations among both capital and labor. Few people have any comprehension of the dire results that would ensue from such a strike as was on the verge of being inaugurated last spring. The following graphic picture of what would result is taken from the Board's report:

The large cities of the East, if the strike had taken place, would have found their supply of many articles of

food exhausted within a week. Of so important a commodity as milk they have not usually more than a day's supply. The loss to the railroads through cessation of business would have been enormous. The total operating revenues of the 52 railroads concerned amount to over $20,000,000 a week. The loss to the engineers would likewise have probably run into the millions. Their present payroll amounts to over $800,000 per week. But the loss to the public would have been vastly larger than that of both parties to the conflict. The great industries depend on the railroads daily for their material, and a week's failure on the part of the railroads to deliver materials to the manufacturers would have made it necessary for many to shut down. Even had they new materials in stock, manufacturers could not long afford to continue producing articles which they had no means of transporting to market. It thus appears that if the strike of railway employees were successful in stopping traffic, its effect upon the industries of the country would be analogous to those of a general strike, simply because a great number of other industries could not continue if the railroads ceased to operate.

If a strike of the character indicated lasted only for a single week, the suffering would have been beyond power of description. Had it continued for a month the loss not only in property, but in life would have been enormous.

Such a disaster would have fallen most heavily upon those least able to bear it. The working classes would have been the ones to feel the soonest, the longest, and the most intensely the unspeakable calamity of a general railroad strike.

It is evident, therefore, that for a great section of the United States a railroad strike can no longer be considered as a matter which primarily affects the railroad operators and employees. The public is far more deeply interested. The interests of the public so far exceed those of the parties to the controversy as to render the former paramount. To this paramount interest both the railroad operators and employees should submit. It is, therefore, imperative that some other way be found to settle differences between railroads and their employees than by strikes.

It may be said by the superficial observer that hitherto railways and their employees have adjusted their differences between themselves and that there is no occasion for the public to interfere. The Commission points out, however, that a new set of conditions has arisen. Formerly each railway company dealt with its own employees. Until 1902, in the settlement of difficulties between the employees and the railroads, no larger units than the railroad systems were usually concerned. Strikes on a single railway system led at times to great disasters; but they did not reach the magnitude of national calamities. In recent years, however, concerted demands for increased wages or changed conditions by employees of all railways extending over a large section of the country have been frequently made. The board states that since 1906 there have been twelve important concerted demands by railway employees in the United States.

In fact the board declares its belief that the power to regulate the rates of railway wages lies today with the employees' organizations rather than with the railway officers.

To expect the employees not to take advantage of this situation would be to credit them with more than human qualities. In common with everyone else, the railway employees and their families have felt the pinch due to the great increase in the cost of living. In common with practically every other class, they hold that this increase in living expenses should be counterbalanced by an increase in income; and having found means by which they can present demands for an increase of wages and practically enforce the granting of these demands, they are not likely to relinquish their power.

The success of the locomotive engineers in gaining an increased wage rate is certain to cause demands from railway labor organizations all along the line. It will be very difficult to refuse these demands in view of what has already been done for the locomotive engineers, together with the undoubted fact that all other clases of railway labor are underpaid as compared with the engineers, combined with the third fact that the demand for labor at the present time gives good reason for increase in wages anyway, in conformity to the law of supply and demand.

On the other hand, it may well be asked, on behalf of the general public, where the increase in railway wages is to stop. Without doubt an increase in railway wages means an increase in railway rates. There is no large margin of profit in the railway business, taking one year with another, which can be drawn upon to stand the increase in wage rates. While at the present season of brisk business the railways are making handsome earnings, their average earnings over a period of years have not kept pace with the increase in operating expenses and taxes. It is clear, therefore, that higher wages to the locomotive engineer, the conductor and the trackman must in the long run be paid by the man who pays the freight—the farmer, the miner, the mill-hand, the laborer.

The plan recommended by the Board for solving this great problem is the establishment by law of national and state wage commissions or labor commissions which should exercise functions regarding labor engaged in the operation of public utilities analogous to those now exercised with regard to capital by the Public Service Commissions already in existence. The Board points out that while the elimination of competition in the railway service has been followed by the assumption of public control through Commissions, the elimination of competition in the labor market is as yet subject to no public control.

To make still more concrete and definite the Board's proposition, it is a fact that the Board has spent months in investigating the special subjects before it. It had to do a great deal of work in the collection of information and statistics, the examination of witnesses, etc. It had to create an organization to carry on this work; and the Board itself was composed of men having other important duties and who could give only a small amount of time to their work on the Board. As a result of all these combined causes, more than six months elapsed between the submission of the case to the arbitrators and the rendering of their final verdict.

If, now, such a Board were a continuing body having power to continuously collect statistics bearing upon wages and wage rates, it would have always at hand ready for immediate use such information as the present Board has been at great expense of labor, time and money to obtain. It could render a just and equitable decision in a week or two as easily as a special Board could obtain the information and pass upon the same questions in six months. We quote as follows from the report:

> Instead of having a Board for each case, which Board has other duties and has wholly inadequate time in which to perform its work, there would be a continuous Board, the members of which would give their entire time to the adjustment of wages. This Board would have a corps of expert statisticians; it would be allowed sufficient time to investigate the case fully. Thus the award would be upon the basis of merit instead of upon the basis of securing a settlement.
>
> Such a Board, moreover, would be able to deal justly with the various classes of railway labor. The relative wages paid to different classes of railway employees at the present time depend not so much upon the relative value and responsibility of the service performed, as upon the extent to which the employees in a particular department are fully organized.

It may be said that should a wage award of such a Commission be unsatisfactory to a group of employees, there would still be nothing to prevent their striking for higher wages. The Board holds, however, that such strikes would be unlikely, since the strikers who refused to accept wages awarded by an impartial government Commission would have no public sympathy back of their movement. If, however, a strike occurred, nevertheless, the question would then arise as to the authority and ability of the government to compel men to continue at work. Concerning this difficult question the Board declares its belief that in the last analysis the only solution is to qualify the principle of free contract in the railroad service.

A strike in the army or navy is mutiny and is universally punished as such. The same principle is applied to seamen because of the public necessity involved. In all these cases the employment, to borrow a legal phrase, is affected with a public use; and this of necessity qualified the right of free, concerted action which exists in private employment. If the principle be accepted that there are certain classes of service thus affected with public interest in which the men who enter them are not free to quit the service in concert, then these men must have public protection as to their wages and conditions, and this the Board believes can best be done through an interstate wage commission.

It is earnestly to be hoped that the recommendations of this Board of eminent men will receive the attention they deserve. Difficult and complex as is the remedy proposed, the public dangers in connection with strikes on public utilities are so great that some means of prevention must be found.

It is especially to be noted that the Board's recommendation covers a broader field than the wages of steam-railway employees alone. The same principle should extend to all public utilities, or to all, at least, in which a general strike would cause great public danger and loss. The threatened strike of the locomotive engineers would have caused calamity because there was no way by which the places of these employees could have been filled if they left work in a body. But wherever the same conditions obtain in any public utility, there exists the same urgent need of some adjustment which will render strikes impossible.

Suppose, for instance, that the men operating the pumping engines supplying a large city with water were to walk out in a body and that it was an absolute impossibility to secure other men to take their places. There would be absolute public justification under such circumstances for the requirement that any man accepting such employment should forfeit his right to combine with his fellow employees to quit work in a body.

Of course, the same thing is even more true of a gas supply where an interruption to the supply and the drop of pressure in the mains may cause enormous damage to life and property. Or again take the fire department of a large city. Every man employed in the department has a right individually to resign his position when he pleases; but for the whole department to conspire together to leave their employment in a body would be only less criminal than a conspiracy to permit general arson.

Or, for still another illustration, take a city's street-railway service. A quarter of a century ago, when there was still more or less competition in the street-railway business, a strike on the lines of one company, while it caused enormous inconvenience and suffering, still left available to the public, in many cases, the cars of some competing company.

The progress of combination has changed all that. In almost every city now, a single corporation has entire control of the entire street-railway system. Hardly a month passes but some city in some part of the United States is not passing through the throes of a street-railway strike with business of all sorts disorganized and interrupted, and often with great danger to and loss of life and property.

Conditions are certain to grow rapidly worse instead of better until it is recognized that the paramount interest in all operation of public utilities is neither that of the owners who hold the stocks and bonds nor that of the employees who run the cars.

There can be no doubt, however, that the right to strike cannot be denied to those employed by public utilities unless some other protection is given them against low wages and improper working conditions. The proposal to create permanent wage commissions, radical though it may seem, is apparently the only way in which a satisfactory solution of the labor question in the operation of public utilities can be brought about.

It is true that Mr. Morrissey, the labor member of the Commission, filed a dissenting report. He approved, indeed, of the proposition to create wage Commissions merely for the purpose of collecting information and data on wages and economic conditions; but he protested against empowering such a Commission to settle a labor controversy by fixing an equitable rate of wages.

Whether this will be the view taken by labor generally remains to be seen. It will be generally admitted that if the labor interest opposes this plan for wage-fixing commissions, or, as they might be called, permanent arbitration boards, there is practically no hope of legislation for their creation; but can labor quite afford to ignore this proposal, made by this body of high-minded and impartial men?

Even if it be true, which we doubt, that the railway employees can secure through their organizations higher wages and better conditions than they could from an independent wage commission, it should not be forgotten that these higher wages will be paid in the long run by other classes of laborers, the workers in mines, factories and mills and stores, the laborers on farms. Moreover, these all, as well as the railway employees, will suffer and suffer terribly if a deadlock occurs and a strike happens extending over a large area of country. In short, the proposition for wage Commissions in public-utility operation is one which deserves the serious consideration of thoughtful men.

Some Sound Doctrines on Good Road Construction*

The American Road Builders' Association is simply what its name indicates: an association of road builders; that is, of men who are engaged in construction and maintenance, whether the work be that of administration, design, supervision, construction or the supply of the materials and plant employed in construction and repairs. That members of the association may be presumed to possess the technical knowledge to enable them to speak with authority upon the technique of road building is further indicated by the fact that of its 24 officers and directors, 15 are members or associate members of the American Society of Civil Engineers.

This is not a propaganda organization. Believing that all intelligent citizens appreciate the great economic value of good highways, we do not feel that it is necessary for us to devote our energies to stimulating good-roads enthusiasm. We believe, however, that a sharp distinction should be drawn between a mere increase in the mileage of smooth road surface and the creation of a carefully thought-out system of highways, skillfully located, well constructed, intelligently maintained and honestly financed. Scientific treatment of the problem of the planning of a highway system is one of the things for which this association stands.

A general plan for a highway system having been formulated, the next step is the determination of the character of the improvement to be adopted for each street or road. The character of the soil, the gradients, the amount and kind of traffic to be provided for, the suitability of local material and the amount of money which is available for the improvement, should all receive careful consideration. Plans for a road's maintenance should be thought out as carefully as those for its construction.

While this association and those who are actually engaged in building and caring for our roads do not greatly concern themselves with campaigns to arouse interest in improved highways and legislation designed to secure them, we must have a keen interest in the manner in which they are to be paid for. We cannot regard with indifference the adoption of a financial policy in connection with road improvement, which, when its folly is realized, will give the cause a serious setback.

The sums required to create and main-

*Extracts from the address of the President, Nelson P. Lewis, of New York, delivered at the opening session of the ninth annual convention of the American Road Builders' Association, Cincinnati, Ohio, Dec. 3, 1912.

tain a good highway system are so great that the first cost must be distributed over a number of years. In the case of any improvement which may be expected to last for several generations, it is but fair that those who are to enjoy the benefit should share the burden. If the improvement will not last for more than a decade, it is obviously unfair for us to buy it and enjoy it during the brief life and incur a debt which the next generation must pay.

It is a practice all too common for our cities and states to pay for their pavements and roads from the proceeds of long-term bonds covering a period several times as long as the probable or possible life of the street or road surface. The recklessness with which such obligations are incurred is alarming, and unless checked will surely lead to disaster.

It is not uncommon for states to issue 50-year bonds to pay for road improvement, and to expend from $12,000 to $20,000 a mile on country roads, the greater part of it on surface construction. If these bonds pay 4 per cent. interest, there will have been expended for interest and amortization by the time the roads are fully paid for, 2½ times the cost of their construction. A simple computation will show that this is equivalent to about $47 an acre on all of the land extending back half a mile on each side of the highway in the case of a road costing $12,000 a mile, and about $80 an acre in the case of a road costing $20,000 a mile. How much of the farm land in the average state has a greater value than this?

But what about the road surface when it is finally paid for? It will have disappeared years before, or it will have been replaced three, four or five times, possibly each time with money borrowed for a long period, to say nothing of the amount expended in ordinary repairs. Or else — and this is an alternative which it is most unpleasant to consider — the next generations, indignant at the burden which we have placed upon them, will conclude that "the game is not worth the candle," will allow their roads to wear out without replacing them, and will relapse into the condition from which we are just emerging.

Do not misunderstand me. I would not question the wisdom or even the necessity of highway improvement on the most extensive scale. There is nothing for which the public is called upon to pay in taxes which will give them a better return for their money, provided always that the roads are intelligently located, and that the type of construction is adapted to the topography, to climatic conditions and to the character of the traffic.

To spend $20,000 a mile where $5000 will answer the purpose, is folly; to select for improvement roads which will be of special advantage to a few prominent political leaders but of little general benefit, is a breach of trust; to pay for them with money borrowed for a term of years far greater than the life of the roads, may appear easy, but it will prove to be very costly in the end. I believe I may speak for this association in saying that it is emphatically opposed to such policies, and that it questions the good judgment and business sense of those who favor them.

Preservation of Steel from Corrosion by the Use of Alkali*

It has been definitely proved that any water made alkaline enough to show 3% of normal alkalinity with calcined sodium carbonate is non-corrosive to steel at all temperatures up to 422° F. Therefore, if the water in the boilers, tanks, evaporators and feed-piping is kept at or above that strength with sodium carbonate at all times, no corrosion will take place, while if the strength is allowed to fall to about 1.8 to 2.5%, bad pitting will take place.

In trying to reproduce the pitting continually taking place in boilers, tanks, piping and on bilge-plates with acid solution, or plain sea or distilled water, the writer failed in every instance on three grades of nearly pure irons, three grades of boiler steel, and on four grades of cast iron. It was easy to produce such similar pittings on all of them when immersed in weak alkaline and very weak carbonate solutions.

For the above reasons it is believed by the writer that much more harm is done in inclosed metal vessels by water made slightly alkaline, either artificially or naturally, than is ever done by the small percentage of acids that ever enters the average boiler. Boilers and other water-containing metal vessels or conduits containing acid water will go to pieces quickly, practically all over at the same time; those containing sea or distilled water will go to pieces all over at the same time, but very slowly; those containing alkaline water of a strength not high enough to stop all corrosion will go to pieces in the weaker places, while other parts or places will remain perfectly good. If the percentage of alkalinity is high enough no corrosion whatever will take place. The reason for this is believed to be as follows:

1. Water has a certain definite potential at any definite temperature.

2. Pure distilled water has a potential lower than that of steels, irons, and some alloys.

3. Acids added to pure distilled water at any temperature decrease its potential.

4. Alkaline substance dissolved in pure distilled water increases its potential.

5. The decrease of the potential of water when an acid is dissolved in it is due to the fact that the negative ion of the acid is lower in potential than that of the hydroxyl OH of water, the H ion being common.

The increase in potential of water when an alkaline substance is added to it is due to the fact that the metallic or positive ion of the alkali is higher in the potential series than hydrogen, while the hydroxyl or negative ion is common to both.

6. When any metal is wet by any water solution, if the potential of the solution is (*a*) higher than that of the metal at every point on its surface, the metal will not corrode; (*b*) higher than some points in the metal surface and lower than that in others, the metal will corrode only over the areas where the potential of the solution is the lower; and it will corrode faster over those points than it would if immersed in distilled water alone (due to the fact that though the difference of potential between that of the metal and that of the alkaline solution is less than it would have been in distilled water, yet the conductivity of the water has been greatly increased by the addition of the alkaline substance); (*c*) lower than that of the metal at any point it will corrode all over at the same time, faster over the higher potential points than over the lower ones. The rate of corrosion over all of the points will depend both upon the difference of potential between the metal at the point and the solution, and also upon the conductivity of the solution.

As the alkalinity of the solution decreases, the difference of potential between the metal and the water increases and the conductivity of the solution decreases until pure water is reached. Any addition of an acid then increases the difference of potential between the metal and the solution and also increases the conductivity of the solution. When considered with a given metal the potential of some alkaline solutions increases faster with a rise in temperature than does that of the metal, therefore a solution that may not be dangerous at ordinary atmospheric temperature may be strongly active to the same metal at higher temperatures. Also a solution that may be strongly active to metals at atmospheric temperatures may be non-corrosive entirely at still higher ones.

The converse may be true with some of the alkaline substances, that is, a rise in temperature may not increase the potential of the solution as fast as it does the metal and a safe solution at atmospheric temperatures may be unsafe at higher ones. In the writer's experiments with alkaline solutions the general rule was that a $\frac{1}{100,000}$ and a $\frac{1}{10,000}$ normal

*Extract from a paper on "The Preservation of Metals Used in Marine Construction," by Lieut.-Commander Frank Lyon, U. S. N., read before the Society of Naval Architects and Marine Engineers, Nov. 21.

concentration of alkaline solutions decreased the rate of corrosion of irons and steels slightly below that in distilled water and caused no pitting, while the $\frac{1}{1000}$ and $\frac{1}{100}$ concentrations increased the rate above that and caused very active local corrosion or pitting until the 2.6% normal concentration was reached, when all corrosion stopped.

In waters that are made non-corrosive to iron or steel by alkaline solutions, their metallic contact with copper and other metals lower than iron in the potential series does not start corrosion.

These notes and observations are made after thirteen years of active sea service as both an engineer and line officer in the U. S. Navy, and after nearly three years' work on corrosion problems at the U. S. Naval Academy.

Foundation Failure of a High Concrete Dam, Port Angeles, Wash.

On Oct. 30, 1912, the gravel and sand underlying a high concrete dam on the Elwha River, about eight miles southwest of Port Angeles, Wash., was washed out, allowing the pond back of the dam to escape down the lower valley and causing considerable damage in that district. The dam itself was left spanning the steep sides of the narrow gorge and apparently was not damaged except in the foundation, as noted below. We have received from Edwin L. Campbell, Assistant City Engineer of Port Angeles, a brief account of the accident, and in addition we have obtained some further information which was not contained in Mr. Campbell's report. Below is given, first, a general account of the failure and following that Mr. Campbell's report.

The Elwha River dam is of peculiar design in that in plan the center of the dam is its narrowest part, with a greater width both upstream and downstream. In addition, the gorge in which it is placed is very narrow (about 35 ft.) and extends upward from the river bottom in steep slope to a point about 20 ft. above high water, where it reaches back on an easy slope to the top of the dam.

The dam is about 110 ft. high, of gravity section and straight in plan. It was built of mass concrete resting on a gravel and sand formation in the bed of the creek. In view of the nature of the gorge it was assumed that the dam would be carried by being supported on the upper shoulders of the banks and by being wedged in the gorge. Attempts were made to deposit the bottom concrete on the bottom laid dry by coffer dams, but this was unsuccessful and most of the bottom concrete was laid under water.

We are informed that the original design was made by L. L. Summers & Co., who started to carry out the construction. In view of the great depth to bedrock, the original design was, as stated above, to hang the dam between the rock walls of the gorge and to put out a deep cut-off wall below it. This work was started by Summers & Co., but the cut-off wall which was sunk failed to prove watertight and they advised the sinking of a caisson underneath the dam in order to reach bedrock. This caisson was started by excavating a horizontal opening into the dam to its center and then sinking directly from the center to bedrock, removing first the concrete of the dam and then the gravel bottom, as each was reached. The caisson was of a width practically equal to the narrowest width of the gorge, and if it had been successful it would have served as a complete cut-off across the gorge. Summers & Co. started this work and in August, 1912, the Olympic Power Co., the owner of the project, took the work over and proceeded to carry it on with its own forces. In September it was found that the concrete which was being excavated and the gravel bottom were so porous that the work could not be continued. Then attempts were made to drive sheet-piling to serve as a cut-off, but this apparently served only to distribute the loose material, and the pressure of the normal pond—100 ft. deep—was too great for the foundation to withstand and the failure occurred, as noted.

Report by E. L. Campbell

The dam of the Olympic Power Co., which was recently underwashed, is situated on the Elwha River about eight miles southwest of the town of Port Angeles. This is a town of some 2500 inhabitants and has been just about where it is for the last twenty years, but seems to be on the eve of a big growth. The town has for the past few years been running its own light plant and in this respect is like the other town on the Olympic Peninsular, Port Townsend. Those now at the head of the Olympic Power Co. saw the approaching development of this peninsula as far back as 1906, and accordingly that same year started preliminary work on the power site on the Elwha River. Peabody, Houghteling & Co., of Chicago, Ill., undertook the financing of the project, and L. L. Summers & Co., engineers, of Chicago, were engaged to design and build the plant.

Summers & Co. made no attempt to find bedrock at the site, but went ahead and designed a gravity section dam 110 ft. high to hold 100 ft. of water. It had two spillways, one on either side of the dam and six penstocks, two of which were for immediate use to operate the two units for supplying power to the peninsular towns and the U. S. Navy Yard at Brementon. These units consisted of a 4800-hp. turbine connected to a 3000-kw. generator each. These penstocks were 9 ft. 6 in. in diameter and operated under a 100-ft. head. The next two penstocks were 2 ft. 6 in. in diameter and supplied power to operate two small exciters, one of 60-kw. capacity and the other of 250-kw. capacity. The remaining two penstocks were 11 ft. 6 in. diameter and were for future use.

Construction was started about two years ago according to these plans and under the direction of L. L. Summers & Co.

By Oct. 30, 1912, the reservoir had filled to about 300 acre-ft., and as the débris and logs from the clearing of the site had not been removed they were floating on the top of the water above the dam. At 7:30 p.m. of that day the washout occurred. The water had seeped under the piling until it weakened this so that it gave way and the water in the reservoir went under the dam with all the force which water under that head can have, carrying with it many of the logs and all the piling and scouring out a hole under the dam to a depth of about 110 ft. It took about 1½ hr. to drain this water out of the reservoir and it went down the river with such force that it tore out one end of the generator room in the power house, about 200 or 300 ft. down the river from the dam. The switchboard was completely demolished and the floor of the room was covered with about 5 ft. of gravel and logs. When, however, the gravel and logs were afterward cleared out it was found that little damage had been done. In fact the switchboard was the only serious loss in this place.

The flood swept down the river with tremendous power and when it reached the county bridge some few miles down the river it completely swept this away and left absolutely no trace of where it had been. Considerable damage was done to property by the flood in its course, but sufficient time elapsed before the flood reached the farms down the river to warn those who were there so that no lives were lost.

Since the accident a number of consulting engineers have been engaged to give their opinion of the situation and find out what can be done; first to complete the project, and second to supply immediate power to the various parties with whom the company has contracts. Among these engineers so engaged are Daniel W. Mead, of the University of Wisconsin; Mr. Maltby, of San Francisco, Calif., and R. F. Haywood, of Vancouver, B. C., who are well known members of the profession.

It is not decided yet just what the course of procedure will be or what these engineers will recommend. There seem to be two general plans under considera-

tion. The first of these is to tunnel the hill to the north of the dam and by means of a coffer-dam divert the stream through this, piping enough water from the coffer-dam to operate the machines. The second plan is to build a temporary rock-fill dam above the main dam and by means of large pipes convey the water to the penstocks and the extra water to the spillways. Attempts are also being made to find bedrock by means of core-drills and by soundings. The large log jam which formed behind the dam when the water went under it is about 500 or 600 ft. long and completely fills the cañon from wall to wall. It must contain about 2,000,000 ft. of lumber, some good and some worthless. Most of this will be burnt out and what cannot be gotten rid of this way will be sent under the dam.

The trouble seems to lie altogether with the design, and therefore the blame falls on the designing engineers. The dam itself, and in fact everything about the plant, stood the shock very well as far as construction under the design could make it stand. Had the dam been built on rock foundation there would have been no trouble whatsoever. As soon as the rock bottom of the river is located there is no doubt that it will be comparatively easy to complete the dam and get the plant in operation.

George A. Glines, of Winnipeg, Manitoba, is president of the company, and Thos. T. Aldwell, of Port Angeles, Wash., is vice-president and general manager. The general offices of the company are at Port Angeles. F. T. Wheeler is resident superintendent at the plant, with G. W. Northrup as the electrical engineer in charge of the power hous

Railroading in New Jersey 57 Years Ago—The following description of a railway accident, found in an old magazine, throws an interesting side light on railway operating methods half a century ago:

The accident occurred on the Camden & Amboy R.R., near Burlington, N. J., Aug. 29, 1855. The morning mail train left Philadelphia at 10 o'clock, reached Burlington at a quarter after eleven, and waited ten minutes for the train due from New York. As this did not arrive, the other train went on for some three miles, when the New York train being discovered, its engine was reversed and the Philadelphia train ran backward toward Burlington at a rapid rate. When near Burlington, a carriage driven by Dr. Heinakin drove upon the track by a road which crossed it, just in time to be struck by the first car of the backing train, which was thrown off the track, dragging three others with it. Three cars were utterly destroyed, and 21 persons were killed and a still larger number injured.

A coroner's inquest was held upon the dead bodies, which resulted in the return of a verdict declaring that the principal cause of the disaster was the carelessness of Dr. Heinakin in driving his carriage upon the track, though the engineer is censured for not having blown his whistle while backing the train. The occurrence elicited very general comment throughout the country, and the railroad company is very severely censured for not constructing a double track upon a route where so much business is transacted.

A Supplemental Report on the Chicago Rapid-Transit Subway Project

The system of subways or underground railways for rapid transit in Chicago as prepared by the Harbor and Subway Commission, was described in our issue of Oct. 3, and since then, public meetings have been held for discussion of the project. Following these meetings, the Commission has (by request of the Council Committee on Local Transportation) issued a supplemental report answering some of the criticisms and objections presented, and from this report we take the following matter. The Commission states, however, that the critics failed to produce any evidence that adequately answers or refutes the main contention of its first report, namely: "Genuine rapid transit in Chicago is impossible without a comprehensive system of municipally-owned passenger subways radiating to outlying sections of the city."

Inadequacy of Present Facilities

The first class of objection is in effect that a rapid-transit subway system is unnecessary, as present and future traffic can be cared for by bringing the surface and elevated roads to modern standards of routing, equipment and service. But with population increasing at the rate of about 500,000 in ten years, and in addition the number of rides per capita increasing 50% in that period, it is considered evident that the existing lines at their highest capacity could not possibly care for the constantly increasing demand for transportation facilities. The present lines give an aggregate seating capacity of about 85,000 passengers during the rush hour, and actually handle about 160,000 during that time, so that even if their capacity was doubled, they would do little more than meeting present maximum requirements. The seating capacity of the subway lines would be 180,000 per hour.

In addition, for a given distance which takes 53 min. by surface lines and 31 min. by elevated lines (express trains), the subway trains are estimated to take only 25 min. The speed of cars on the surface lines will always be limited on account of crossing stops (so that these lines can hardly be considered as giving rapid-transit service), and the trains on the elevated lines are subject to great delay while on the loop through the business district. From an analysis of the conditions it is believed that one of the strongest arguments for subway lines extending into the outlying districts is that speed, comfort and safety can be maintained uniformly during a continuous ride, whether for a short or long distance. The actual saving of time to the passengers would be enormous in the aggregate.

Cost and Revenue of Subway Lines

The second group of objections is to the effect that the subway system would not be a success financially, the present and future traffic being insufficient to support this system in addition to existing means of transportation. The Commission points out that it has endeavored to avoid the theory (which is universal in the laying out of privately owned transportation lines) that new rapid-transit subways should be built only where they will yield an immediate profit from operation. The estimated capital cost of the proposed lines (including equipment) is $131,000,000, and 10% on this would be required annually to pay fixed charges, as follows: Operating expenses, 4% (40% of the gross earnings from operation); interest on capital, 5%; sinking fund for extinction of capital debt, 1%. The estimated population of the area within half a mile of the proposed lines is 1,825,000, and at 395 rides per capita per annum there would be 719,000,000 rides or a total revenue of $35,950,000; while the revenue required to pay 10% on the capital investment is only $13,100,000, requiring but 262,000,000 rides. This is only a little over one-third of the available traffic within the subway zone.

The estimate of 40% for operating expenses is considered to be very reasonable. The operating expenses of the New York subway of 1910, including taxes, were 35.75%. As to objections claiming that the cost of construction has been estimated at too low a figure, the Commission states that this was based on detailed estimates. For each zone, the typical construction was taken, quantities were figured, and unit prices were assumed which were purposely higher than those for which the work could be let if bids were invited. The general average cost of $730,000 per mile of single track was based upon these liberal detailed estimates. In addition to this, it is shown by the report that in 1910 the average cost of the New York lines was $784,350, and that of the Fourth Ave. line in Brooklyn was $855,000 (due to specially difficult work involving crossing under the subway at two places), while a bid for a line at Toronto was $539,400 per mile. As to the effect of the subway lines upon existing lines, it is believed (on the basis of experience elsewhere) that the former will not only create traffic for themselves, but increase that of the latter.

Congestion of Traffic

Another objection made was that an independent system of municipal subways would increase rather than diminish, the traffic congestion of the down-town or business district. But this the Commission answers by showing that this district is only a midway point on the pro-

posed subway lines, instead of being a terminal point as on the present surface and elevated lines. The estimate capacity of the subway lines is 180,000 seats per hour, and this, in conjunction with the higher speed obtainable through this congested district, should materially relieve the traffic on the surface lines. In addition to this, the improved transportation facilities would tend to increase the area of the business district, thus relieving the present condition of over-concentration.

Effect on Outlying Districts

An objection urged in behalf of the local business districts outside of the down-town district was that the effect of the subway system would be to develop or build up the latter district at the expense of the former districts. In other words, that it would be so easy for shoppers to go down-town that they would neglect their local groups of merchants and stores. To this it is replied that in all the outlying districts of Chicago the extension of a surface or elevated line into new territory creates new local business sections and increases the value of real estate. The same is true of New York, one example being an increase in surface-car traffic in the Borough of Bronx of 138% in five years, due to the opening of subways and their beneficial effect upon the growth of the outlying districts.

Down-town Subways for Existing Lines

A fifth objection was to the effect that long-distance subway lines are unnecessary and that requirements will be met by local subways in the down-town district, to be used by the present transportation lines, so as to reduce the traffic congestion on the streets within this district. As it is assumed that these local subways would be built by the city and leased to the companies, the former would bear the real financial burden. The companies would determine the quality of the service, and would receive a fixed share of the surplus profits after all guaranteed fixed charges had been met. This is the system embodied in some of the earlier subway projects, but was rejected by the Commission (and the Council sub-committee) as inadequate to meet the conditions and requirements. The report shows how such financial or contractual relations between the city and the present companies would be adverse to the city's interests, both as to financial matters and as giving undue powers to the companies.

As to relieving congestion by diverting some of the present surface cars and elevated trains into down-town subways, it is shown that the capacity would be very small as compared with that of the independent subway system. Allowing surface cars at 20 sec. headway and 40 seats per car gives only 7200 seats per hour; ten-car elevated trains (50 seats per car) at 1½ min. headway would give only 20,000 seats per hour. That is, a total of 27,200 seats per hour, as compared with 180,000 for the independent subway. Further, with so many street-car routes, it would be necessary to have a certain percentage of cars from each route pass through the subway, or there would be complaint of discrimination. But to thus divert cars from each route would mean confusion in approaching and leaving the subways, and still greater confusion at the subway stations owing to the various destinations of the cars. The loading and unloading of these cars would determine the headway. Another difficulty is that the street cars have low floors approached by steps, while the elevated-railway cars have high floors for use with high platforms at the stations. The report states as follows:

"If rapid-transit subways are built, surface-car subways will not be necessary because the greater percentage of surface cars coming into the down-town district from the outlying districts can be discontinued and be used for local or short haul, thus relieving the surface lines of the long haul which they claim is unprofitable. A surface-car subway would take 180 cars off the streets. A rapid-transit subway would take 500 cars off the streets, at the same cost."

Notes from Engineering Schools

Syracuse University—The New York State College of Forestry has developed a four-year course for the training of city foresters. It has been found that many villages, towns and cities in New York are interested in the proper development of street and park planting, while many larger cities are already employing trained foresters; this course has been arranged to supply the expected demand for men trained for this service. For a year and a half the course will consist of fundamental work in botany, chemistry, geology, soils, mathematics and surveying. Beginning with the sophomore year will be given courses in forestry, arboriculture, etc. There will be special courses in forest entomology and pathology and in the use of spraying methods and materials. There will be practical work in plane and topographical surveying to enable the students to lay out for planting streets and public and private grounds or parks.

Cornell University—An interesting investigation into the cost of living at the University has recently been made by Prof. Walter F. Willcox, of the Department of Economics. This investigation was made in the Fall of 1911 and is compared with a similar investigation made in the Fall of 1896. In the later study, 90% of a student body of 3927 satisfactorily answered the inquiries as to the cost of board and room rent. At the earlier inquiry 80% of the student body forwarded satisfactory answers. The comparisons briefly stated are as follows: The cost of room rent in 1896 averaged $2.07 per student, and in 1911, $2.82 per student, an increase of 36%. The cost of board in 1896 averaged $3.46 per student, and in 1911, $4.53 per student, an increase of 31%. The total values, then, for room and board in 1896 were $5.53, and in 1911, $7.35, an increase of 33%, or approximately 2% per year increase for the necessities of life. Doubtless at the same time the cost of tuition and of luxuries have similarly increased as well. Prof. Willcox did not carry his investigation into the faculty, but it probably would be found that an increase would show there, although there has not been a very great increase in the salaries awarded professors since 1896.

Coal Reserve of the United States—The known coal fields of the United States embrace a total area, according to the U. S. Geological Survey, of 310,296 sq.mi., to which may be added something over 160,000 sq.mi. of which little is known, but which may contain workable coals, and about 32,000 sq.mi. where the coal lies under heavy cover and is not considered available under present conditions. The supply of coal before mining began is estimated to have been 3,076,204,000,000 short tons, of which 1,922,979,000,000 tons were considered to be easily accessible and 1,153,225,000,000 short tons to be either so deep or the beds so thin that they are accessible only with difficulty. Classified according to the character of the coal, the original supply consisted of 21,000,000,000 short tons of anthracite, 1,661,457,000,000 tons of bituminous coal, 650,157,000,000 tons of sub-bituminous coal, and 743,590,000,000 tons of lignite.

The total production of coal to the close of 1911 has amounted to 2,270,798,737 short tons of anthracite and 6,468,773,690 tons of bituminous coal, or an aggregate of 8,739,572,427 tons. This total production to the close of 1911 represents, including the waste of coal in mining, an exhaustion of the beds equal to 14,181,980,000 short tons, or somewhat less than 0.5% of the original supply. In other words, the quantity of coal still remaining to be mined amounts to 3,062,022,020,000 short tons, or a little more than 99.5% of the original supply. The annual rate of exhaustion at the present time as represented by the production in 1910 and 1911 is 0.025% of the supply. The quantity of coal still in the ground at the close of 1910 was 6000 times the production of that year, or, estimating a half ton of coal lost for every ton recovered, the supply is equivalent to 4000 times the present annual rate of exhaustion.

A 286-ft. Concrete Arch—A reinforced-concrete arch bridge now building in Switzerland exceeds in span all previous Swiss arches of the same material, and ranks fourth or fifth in the world. It is located near the city of Bern, crossing the Aare River, and is a highway bridge, with 30-ft. roadway. The deck is about 130 ft. above river level. ("Technische Monatshefte," Nov., 1912).

The Award of the John Fritz Medal will be made at a joint meeting of the civil, mining, mechanical and electrical engineering societies at New York, on Dec. 5. The medal is to be presented to Mr. Robert W. Hunt, for his contributions to the early development of the Bessemer process of steel manufacture.

The Igniting of a Film in a moving picture theater at Bilboa, Spain, on Nov. 24, caused a panic among the spectators and about 50 of them, mostly children, were killed in the struggle to escape. The operator succeeded in putting out the blaze unassisted after his cry of "fire" had started the panic.

In a Mine Cave-in at the Barnum Colliery No. 2 of the Pennsylvania Coal Co., at Wilkes-Barre, Penn., on Nov. 25, 14 men were injured, 7 seriously. The press accounts state that the cave-in was expected and that efforts were being made to provide extra timbering in order to prevent the accident, but this work was not started soon enough.

An Explosion Occurred in the dry-starch house of the Corn Products Refining Co.'s plant at Waukegan, Ill., on Nov. 25, and a number of employees were killed and injured and a property loss of about $100,000 was sustained. The exact cause of the trouble is not known, but it is thought that the explosion came from overheating of the material in the large starch kilns.

Public Health Week is being celebrated in Syracuse, N. Y., from Dec. 1 to 6 inclusive, by sermons and lectures on different phases of the problem of municipal sanitation. Prominent state officers and physicians are giving short talks daily, on personal hygiene and on means for preventing the spread of disease through infected food. Popular interest is being stimulated by the use of moving pictures to supplement the lectures.

A Typhoon Caused Heavy Damage in the town of Tacloban, Leyte, P. I., on Nov. 25, according to press dispatches, which also state that considerable damage was done at Capiz, on the island of Panay. The first mentioned city had 14,000 inhabitants and was the outlet from the hemp district. Reports from the neighborhood are vague, but it is feared that Tacloban was almost completely destroyed and that several thousand lives were lost.

A Big Fire Broke Out in Brooklyn, on Nov. 25, in the plant of the Union Sulphur Co., following several explosions in the sulphur storage bins, and for a while the blaze threatened to spread to the large neighboring oil and gas storage tanks. A strong wind was blowing at the time of the fire and the sparks set fire to a large hay storehouse and to several frame dwellings. The known injured were 40 in number, of whom 4 are not expected to survive, and it is also supposed that several employees were caught in the burning factory.

Fifty-million Dollars for Additional Highways was authorized to be procured by a 50-year bond issue by the voters of the state of New York, in the recent election. The referendum, which had been passed by two successive legislatures, as required by law, was passed by a majority of 400,000. This is the second appropriation of like amount made by the state in the past five years, the first $50,000,000 being already exhausted in construction.

It is announced that Gov. Dix has refused the $10,000 federal appropriation for post roads, authorized to be granted each state by a recent Act of Congress.

Compulsory Workmen's Compensation Insurance was advocated at a conference in New York City during the past week, presided over by August Belmont. An effort is to be made to have uniform laws passed on this question by the 38 state legislatures which go into session after Jan. 1.

Rather than rely on state insurance, which has been successful under certain conditions and a failure under others, and in order to avoid the dilemma of the workman being awarded damages for injury sustained and still being unable to collect because of his employer's insolvency, a system of compulsory insurance taken out with regular insurance companies and under state supervision is advocated.

A Bridge Failure and Train Wreck occurred in combination on the Pennsylvania R.R. main line at Glen Loch, Penn., 25 miles west of Philadelphia, on Nov. 27, shortly before midnight. Four persons were killed and many injured in the wreck. A westbound fast passenger train consisting of two locomotives and twelve cars, the last nine sleepers, was derailed at a plate-girder bridge about 150 ft. long. The third car and six sleepers went down the bank just beyond the bridge, while the locomotives and first two cars, and the last three sleepers remained on the track. The killed were in the first sleeper. The small number of casualties is generally credited to the fact that cars were of steel construction.

The bridge in question crosses a two-track railway line, and consists of two spans of through plate-girders, supported by a braced bent of latticed columns between the two tracks below. The bridge is rather old, but was in good condition, and had been regularly and thoroughly inspected, according to testimony at the coroner's inquest. After the wreck it was found that the bridge was deflected downward about 1½ ft. at the middle support, having crushed the cap of the column. It is said that the cap plate of the column under one of the girders was broken. Nothing has been determined definitely as to whether the derailment occurred before or after the bridge failure. A committee of Pennsylvania R.R. officials, the State Railway Commission, and the Interstate Commerce Commission have started investigations.

The Progress of Subway Work in New York City is summarized in an announcement of Chairman W. R. Wilcox, of the Public Service Commission for the First District, State of New York, that conferences between the Commission, the Interborough Rapid Transit Co., and the Brooklyn Rapid Transit Co. on the operating contract for the dual system of rapid transit (see Engineering News, May 23, 1912, p. 1008), are drawing to a close, and that within a short time the Commission will advertise these contracts for public hearing. By these the companies mentioned will get an operating lease for 49 years of the new subway and elevated lines in the dual system, as respectively allotted to them. It will be recalled that this system, together with the facilities already in operation, will provide rapid-transit lines up and down the east and west sides of New York City, together with branches in the Boroughs of the Bronx, Brooklyn, and in the distant future, one branch to Richmond (Staten Island).

Aside from the operating contracts, construction work on the Lexington Ave. line in Manhattan, Brooklyn and the Bronx is going on to the extent of $70,000,000. Consent of property owners is being obtained on some of the new routes, and on others the Commission has applied to the Appellate division of the Supreme Court for a determination in lieu of such consent. The engineering department is advancing work on the plans and supervising construction under way. The first part of the new dual system will probably be placed in operation during 1913. This will be the Fourth Ave. subway in Brooklyn from the Manhattan Bridge and its connection in Manhattan Island with the Centre St. loop subway. This connects the Williamsburg and Manhattan Bridges over which trains will enter Manhattan Island from the 4th Ave. subway and the Brooklyn Rapid Transit elevated lines. This part of the dual system will be operated by the New York Municipal Ry., a company organized by the Brooklyn Rapid Transit Co. for this purpose.

Turnstiles on Prepayment Type of Street Cars have been prohibited in Dayton, Ohio, by an order of the Ohio Public Service Commission, dated Oct. 8, 1912. The Commission began, in May, an investigation of the safety and security of operation of the Peoples' Ry., especially in the matter of the use of turnstiles at the points of car entrance. It was found that the turnstiles were wood and metal devices used for registering the number of persons entering the cars. These were attached to the vestibules of the cars so as to form a rigid obstacle and an impassable barrier in the way of passengers or persons seeking to enter or leave the car until the machinery was released, allowing the arms to turn or fall. It was found that this at times resulted in bruising or injuring passengers attempting to enter when passenger and conductor failed to act in exact unison. It was also found that the turnstiles created an additional element of danger in case of accident or other emergency necessitating prompt unloading of passengers.

Personals

Mr. A. A. Sinclair has been appointed Superintendent of Bridges and Buildings of the Duluth, Missabe & Northern Ry., with headquarters at Duluth, Minn.

Mr. John G. Berquist has resigned as Works Manager of the Universal Portland Cement Co., Chicago, Ill., but he will retain a connection with the company as Consulting Engineer.

Mr. B. A. Brackenbury, Chief Engineer of the sewer department of Spokane, Wash., has resigned to accept a position with Carson & Earles, of Seattle, Wash. Mr. A. I. Buchecker, of the city engineering department, succeeds Mr. Brackenbury as Engineer in charge of sewers.

Mr. Walter Rachals, formerly Chief Engineer of the National Steel Co., of Pittsburgh, Penn., and recently Manager of Mr. Julian Kennedy's engineering office, Pittsburgh, has accepted a position in charge of the iron and steel works department of the Westinghouse, Church, Kerr & Co., Pittsburgh.

Mr. Cyril J. Atkinson, M. I. Mech. E., inventor and patentee of the Atkinson gas producer, has resigned his connection with the Dornfeld-Kunert Co., Watertown, Wis., to become associated with Fairbanks, Morse & Co., of Chicago, Ill. Mr. Atkinson's patents will be incorporated in the Fairbanks-Morse gas producers.

Mr. Leonard Wesson, Superintendent of Plant No. 2, of the Universal Portland Cement Co., South Chicago, Ill., has been promoted to be Assistant to the President, with headquarters at the general offices of the company, Chicago, Ill. Mr. Wesson is succeeded as Superintendent by Mr. Nels Nelson, hitherto Assistant Superintendent.

Mr. S. A. Jubb, Assoc. M. Am. Soc. C. E., Consulting Engineer of San Francisco, Calif., and formerly associated with Mr. E. P. Goodrich, M. Am Soc C. E., in the development of the Bush Dock & Terminal Co. property in Brooklyn, N. Y., has been appointed Assistant Chief Engineer of the Bureau of Harbor Improvement, Los Angeles, Calif.

Sir Alex. M. Rendel, M. Inst. C. E., announces that he has taken into partnership with him, Mr. Seymour B. Tritton, M. Inst. C. E., who has been associated with Sir Alex. M. Rendel and the late F. E. Robertson for the past 20 years. The firm will hereafter be known as Rendel & Tritton, of 13 Dartmouth St., Westminster, S. W., London, England.

Mr. Malcolm A. Rue, Assoc. M. Am. Soc. C. E., formerly Chief Engineer of the Robert Wilson Co., Consulting Engineers, New York City, announces that he has opened an office at 200 Fifth Ave., New York City, as a consulting engineer. Mr. Rue was for ten years in the designing department of the American Bridge Co., and will specialize in building construction work.

Mr. N. D. Maher, General Manager and Second Vice-President of the Norfolk & Western Ry., has been elected Vice-President in charge of operation. Mr. Maher is succeeded as General Manager by Mr. A. C. Needles, former General Superintendent of the Eastern division, at Roanoke, Va. Mr. V. A. Riton, Division Superintendent, at Crewe, Va., succeeds Mr. Needles as General Superintendent.

Mr. D. G. Baker, M. Am. Soc. M. E., Works Manager of the Olds Motor Works, Lansing, Mich., and formerly Works Manager of the Blake & Knowles Steam Pump Works, Cambridge, Mass., has been appointed Works Manager of the Carels Freres' Diesel engine plant at Ghent, Belgium. Mr. Baker has just returned from a trip to Ghent where he concluded final arrangements with the directors of the company, and is now preparing to sail in a few days with his family for Europe.

Obituary

Howard James, Director of Purchases, and S. B. Plechner, Purchasing Agent, of the Great Northern Ry., at St. Paul, Min., were killed in an automobile accident near St. Paul, on Nov. 24.

Walter Tomkins, President of the Tomkins Cove Stone Co., Tomkins Cove, N. Y., died Nov. 26. Mr. Tomkins was 51 years old and a brother of Mr. Calvin Tomkins, Commissioner of the Department of Docks and Ferries, of the City of New York.

John J. Keefe, Southern Representative of the Independent Pneumatic Tool Co., at Atlanta, Ga., died Nov. 20, from typhoid fever. Mr. Keefe was born in Susquehanna, Penn., 46 years ago. For a number of years he served in the mechanical departments of various railways until about 10 years ago, when he entered the railway supply business.

Forrest H. Rawson, Resident Engineer for H. S. Ferguson, M. Am. Soc. C. E., Consulting Engineer, New York City, died at his home in Glens Falls, N. Y., Nov. 21. Mr. Rawson graduated in civil engineering from Cornell University in 1910. While employed with Mr. Ferguson he had been in charge of construction of the Tide Water Paper Mills, Brooklyn, N. Y. Previous to his position in Brooklyn, he had been Inspector, U. S. Engineer Office, Sault Ste. Marie, Mich.

Alexander G. Hackstaff, Vice-President of the Illinois Central R.R., in charge of the New York City office, died at his home in New York, Nov. 28. Mr. Hackstaff was born at Middletown, Conn., May 16, 1852. He entered the railway service in 1871 in the civil engineering department of the Pennsylvania R.R. In 1880 he went to the Illinois Central R.R. and 7 years later was appointed Acting Secretary. He was chosen Secretary in 1888 and held this position for many years.

Engineering Societies

COMING MEETINGS

AMERICAN ROAD BUILDERS' ASSOCIATION.
Dec. 3-6. Annual convention at Cincinnati, Ohio. Secy., E. L. Powers, 150 Nassau St., New York.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.
Dec. 3-6. Annual meeting at New York City. Secy., C. W. Rice, 29 W. 39th St., New York.

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS.
Dec. 4-6. Annual meeting at Detroit, Mich. Secy., J. C. Olsen, Polytechnic Institute, Brooklyn, N. Y.

NATIONAL HOUSING ASSOCIATION.
Dec. 4-6. Annual conference at Philadelphia, Penn. Secy., Lawrence Veiller, 105 E. 22d St., New York.

NATIONAL SOCIETY FOR THE PROMOTION OF INDUSTRIAL EDUCATION.
Dec. 5-7. Annual convention at Philadelphia, Penn. Secy., C. A. Prosser, 105 E. 22d St., New York.

ASSOCIATION OF AMERICAN PORTLAND CEMENT MANUFACTURERS.
Dec. 9-12. Annual meeting at New York City. Secy., Percy H. Wilson, Land Title Bldg., Philadelphia, Penn.

AMERICAN INSTITUTE OF ARCHITECTS.
Dec. 10-12. Annual convention at Washington, D. C. Secy., Glenn Brown, The Octagon, Washington, D. C.

NATIONAL ASSOCIATION OF CEMENT USERS.
Dec. 10-14. Annual convention at Pittsburgh, Penn. Secy., E. E. Krauss, Harrison Bldg., Philadelphia, Penn.

AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS.
Dec. 26-28. Annual meeting at Chicago, Ill. Secy., C. O. Reed, Urbana, Ill.

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.
Dec. 30-Jan. 6. Annual meeting at Cleveland, Ohio. Secy., L. O. Howard, Smithsonian Institution, Washington, D. C.

MINING AND METALLURGICAL SOCIETY OF AMERICA.
Jan. 14. Annual meeting at New York City. Secy., W. R. Ingalls, 505 Pearl St., New York.

AMERICAN WOOD PRESERVERS' ASSOCIATION.
Jan. 21-23. Annual convention at Chicago, Ill. Secy., F. J. Angier, B. & O. RR., Baltimore, Md.

New England Water Works Association—On Dec. 11, a meeting of the Association will be held in Boston, at which time the following papers will be presented: "Uses and Abuses of Water Filtration," by Gilbert H. Pratt, and "The Las Vegas Dam," by William T. Barnes. Folowing the reading of the papers, a discussion will be held on the topic of "Paint for Standpipes and Methods of Applying."

National Association of Cement Users—The program for the annual convention, to be held in Pittsburgh, Penn., Dec. 10-13, has been materially changed from that published in Engineering News, Nov. 21, 1912, p. 984. The main portions of the new program are as follows:

Dec. 10, 8 p.m.—Formal opening of the convention, Fort Pitt Hotel; The Use of Concrete in Irrigation Work, Arthur P. Davis.

Dec. 1, 10 a.m.—The Present Status of Patents Applying to Reinforced-concrete Construction, W. M. Denman; Vibrolithic Concrete Pavements, R. C. Stubbs.

Dec. 11, 3 p.m.—The Effect of Electric Current on Concrete, E. B. Rosa, Burton McCollum and O. S. Peters; Fire Test of Plastered Partitions, L. H. Miller; Discussion on Metal Lath Construction; H. B. McMaster; Tests of Waterproofing for Concrete, Cloyd M. Chapman.

Dec. 11, 8 p.m.—Annual address by the President, Richard L. Humphrey; The Use of Concrete by the Bureau of Yards and Docks, H. R. Stanford; Reinforced Concrete in Railroad Work, M. A. Long; Application of Concrete in the Abolition of Grade Crossings, James W. Phillips; Some Recent Applications of Concrete in Railroad Work, Frederick Auryansen.

Dec. 12, 10 a.m.—Recent Applications of Concrete and Reinforced Concrete in the City of Pittsburgh, Norman S. Sprague; The Present Status of Unit Methods of Reinforced Concrete Construction, John E. Conzelman; Concrete Grain Elevators, R. P. Durham; Barney Weller.

Dec. 12, 3 p.m.—Principles of Design and Results of Tests on Girderless Floor Construction of Reinforced Concrete, T. L. Condron; Measurement of Actual Stresses in a Cantilever Flat Slab Reinforced Concrete Floor Having Rectangular Panels, Arthur R. Lord; Rigid Frames and Arches of Reinforced Concrete in Building Construction, Sanford E. Thompson; Tests to Determine Lateral Distribution of Stresses in Wide Reinforced Concrete Beams, W. A. Slater.

Dec. 12, 8 p.m.—Opening of Cement Show.

Dec. 13, 10 a.m.—The Constitution of Portland Cement. Some Results Obtained at the Experimental Cement Plant of the Bureau of Standards, P. H. Bates; The Progress of the Work in Cement and Concrete of the Bureau of Standards, Rudolph J. Wig; Sand and Gravel Washing Plants, Raymond W. Dull.

Dec. 13, 3 p.m.—The Manufacture of Concrete Products (Artificial Stone, Cement Pipe, etc.) in Germany, Julius Carstanjen; The Coloring and Texture of Concrete Products, Adolph Schilling; Silos and Small Grain Tanks of Concrete, E. S. Fowler.

Dec. 13, 7:30 p.m.—Annual banquet.

Dec. 14, 9:30 a.m.—Visit to United States Government Testing Laboratories.